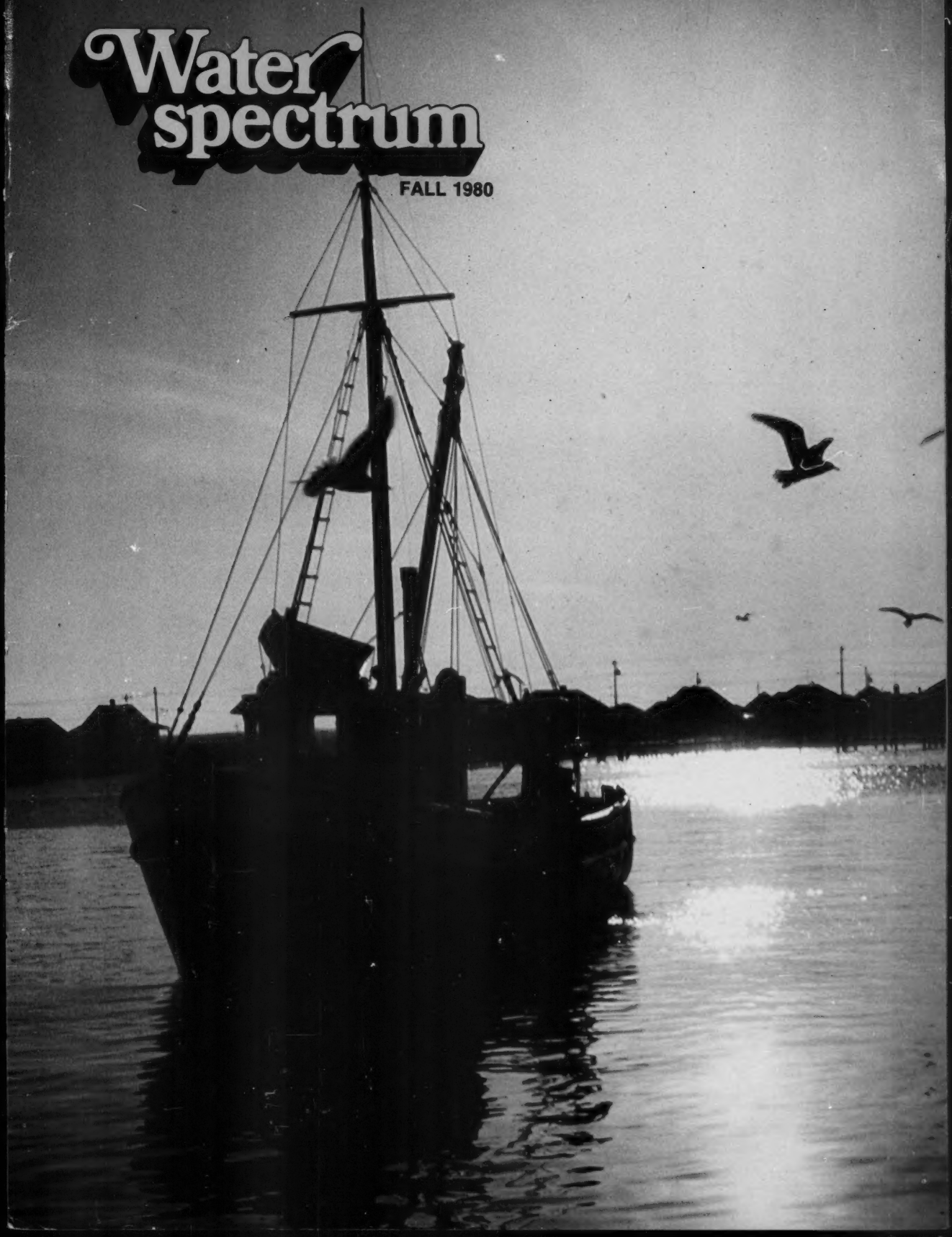
Water spectrum

FALL 1980



Water spectrum

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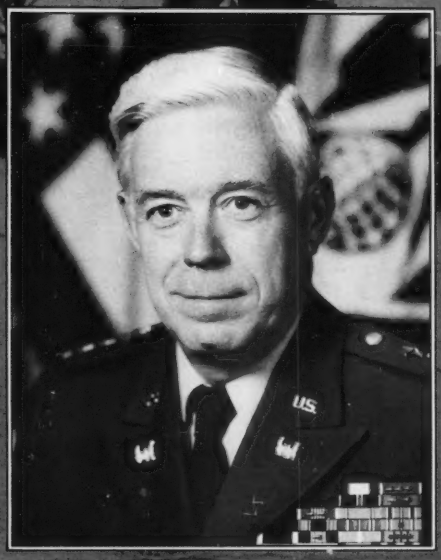
COVER: "The gray-green stretch of sandy grass,
Indefinitely desolate;
A sea of lead, a sky of slate;
Already autumn in the air, alas!"—Arthur Symons

(Photo by John C. Fine)



REFLECTIONS:
An Interview With The Chief

Lieutenant General J. W. Morris retired in September as Chief of the U. S. Army Corps of Engineers. Ann Hoffnar of the Corps' Civil Works Directorate talked with the general for *Water Spectrum* readers prior to his departure.

General Morris, from your days as Division Engineer, Missouri River Division, through your days as Chief of Engineers—this roughly corresponds to what you've called the "decade of the environment"—what do you see as the Corps' greatest achievements in the area of environmental protection?

Probably the greatest achievements are not as much related to specific projects—although there are many of those—as to our change in direction, so that we could accommodate national environmental objectives. Changing a large organization is always difficult but we changed our policies and set up the mechanisms to incorporate environmental law into our operations. Environmental planning is now part of our daily business. We have biologists, fish and wildlife experts and scientists from other related fields on our team. Without these changes we could never have moved in the direction that the country wanted to go.

General Morris, in 1975 you told us at *Water Spectrum* that protection of the wetlands must be given high priority. Didn't this turn out to be a bigger task than we anticipated?

The answer is generally yes. Of course, by 1975 we were pretty well aware of what this job was going to involve. When the Federal Water Pollution Control Act Amendments passed in October 1972, we were given increased responsibility, under Section 404, for regulating construction or any other development of the wetlands through a permit process. You may remember our traditional definition of navigable waters was quite restricted. The new law and subsequent court cases broadened "navigable waters" to include all the waters of the United States. This, in effect, increased our authority to grant permits many fold. At first we really didn't anticipate the complexity of the program. Its size—based on sheer numbers of permit cases—is staggering and many of the cases are quite controversial and complex. Among our most difficult permit decisions were to deny the permit for development on Marco Island, Florida and to approve the permit for a refinery at Newport News, Virginia. There have been many other difficult decisions.

It's been a good program though; I wouldn't want to let the magnitude of the work be misconstrued. I think we've handled it well. The Corps has earned a reputation as fair and thorough throughout government and private industry as well as the environmental community.

You've said that the 80s are going to be a decade of conservation. To our agency of course this primarily means water conservation. I've heard several definitions. Do you have one that's really satisfactory?

Yes, my Civil Works staff has come up with a definition which makes sense to me. It simply says that water conservation is any beneficial reduction in water use or in water losses. Both reduction in use and loss make water for other uses. It's a rather short and I think useable definition.

In his water policy the President has stressed conservation. I believe the Corps has now worked out a plan of action to implement the President's policy. Can you tell me something about it?

Yes, early in his tenure I had an interview with the President. We talked about the future of the Corps and its programs. One of the last things the President said was "I wish you would develop a water conservation program." This request was never put in writing but when you get a request like that from the President it's usually enough. So we have worked very hard in this area since that conversation. First we surveyed the literature and then developed our definition of water conservation. We developed a plan

Art Klein, a Permits Investigator in Buffalo's Regulatory Functions Branch, examines plant life in a Niagara County, New York wetland.

of action for integrating conservation measures into five Civil Works program areas: planning, design and construction, reservoir regulation, operation and maintenance, and regulatory activities. We sent the plan to our field offices in May of 1979 and this May we sent an updated version. Our water conservation program is a solid one that addresses water conservation as part of our own use of water and of our planning for future water needs of the public. We are drawing up contingency plans to make existing Corps projects responsive to short-term water shortages during droughts. We are also considering water conservation in our permit program's public interest review.

Up to the present time the role of the Corps has been limited primarily to water supply as a part of multiple purpose Federal projects. In 1975 you talked about planning for water supply. Will conservation be enough? Do you see our role in water supply increasing in the 80s?

I don't think conservation will be enough. In my talk down in New Orleans earlier this year I said that developing a water conservation plan is just a first step. That done, we will find that our needs still exceed our present supply. Therefore, we'll need to store excess water in time of plenty so that it will be available for shortages. The question then becomes "who's going to develop water supply?" Congress has already selected the Corps of Engineers to study water supply in the northeast United States and I'm of the view that the Corps is probably the best agency, but not the only one, to do it nationwide. I've thought for some years now that we should be given a charter by the congressional authorization committees to undertake a national water supply study. I believe the appropriations committees would be willing to provide the money, but there is a preceding question which relates to authority to make the study. Water supply is certainly in somebody's future; I would hope it will be the Corps'.

Corps park ranger talks with children.

You told the Water Resource Congress in New Orleans in February—I think the same speech you just referred to—that it was time for water resources developers to get back to work. How does this jibe with today's stress on conservation and our country's money problems?

It relates directly to conservation because in that speech I said we can't really get back to work until we have integrated conservation into our water planning, just as we integrated environmental criteria. We've got to be able to demonstrate to the people that we've observed conservation measures. The nation's current economic difficulties are another matter. I suspect that we risk being delayed more by money than anything else, but I foresee a fairly large investment in the water program. There's much to be done. I believe the necessary conservation measures, and our economic problems will affect *when*, not *if*, we resume developing water resources.

Our decision to maintain a minimum fleet and contract out some of our dredging marks a new era in water resources development. It must have made you nostalgic when the dredge Essayons was retired.

It did. The Essayons, though, was retired for two reasons; one, she's not really sea-worthy any more, and the cost to fix her up was prohibitive. And two, we do have a new larger dredge coming into service very soon. Our fleet is changing though because the dredging industry is putting the hopper dredge business into the national private enterprise system.

I think the program that put dredging out into the competitive arena is already proving to be a good idea. Though it was painful for our people to give up those missions, the taxpayers are now getting a lot more dredging for their money because of competition. The government fleet wins some dredging contracts and the private industry fleet wins some but in each case the lowest price gets the job. The accumulated savings are mounting every year by millions of dollars.

Energy is clearly a high priority. How do you expect the new national emphasis on energy to affect Corps programs.

It already has. We are fortunate that we were able to get a couple of studies going four years ago—before the energy crunch worsened. Those studies will soon be available. One of them, the National Waterways Study, has to do with water transportation, which indirectly affects energy because so much of the cargo transported is coal and other energy products. The

The Essayons.

other study is of hydropower, which of course has a direct impact. We are looking at all the potential large and small scale dam sites in the country. I think the study is going to prove we can at least double our hydropower output. We are assessing all forms of hydropower potential: lowhead, pumpback, run-of-river, major power projects, and additions to existing projects. It's going to be a most helpful study.

The Corps has studied, as you said, the nation's waterways and its hydropower resources. Do we need a national flood management study?

Well, we need to at least identify the major flood problems in the United States. Some people seem to

Lock #1 on the Green River, Louisville District.

believe that there are few real flood problems left. This is not the case, and a worthwhile effort could be made to describe the extent of the major flood problem areas and the best means to deal with them. We have perhaps ten or twenty places in the country where people are literally sitting on a powder keg, and they are going to get hurt unless we do something about it.

We hear a lot about non-structural solutions to flood problems now. Is this the solution of the future?

Non-structural measures alone cannot solve all our problems. However, non-structural solutions are considered in every situation we encounter—flood control as well as other water resources projects. We seldom develop a plan that is totally non-structural or totally structural. We integrate both methods on a case-by-case basis.

What about the results of our dredged material research program? Did they provide the guidance you expected and was it worth 30 million dollars?

It was worth $30 million; in fact it's paid for itself already. The study was targeted at a national attitude that all dredged material is polluted and automatically bad. This study was started back in the very early 70s and what it's done, if it's done nothing else, is proven to the world that most dredged material is *not* bad. As a matter of fact, a very high percentage of it is useable material and really a national asset. If it did nothing else, that valuable goal was accomplished. In addition we learned some new techniques for storing dredged material: how to handle it, what kind of dredges to use and many other things. In the Great Lakes alone we saved over $20 million right off the bat since we didn't have to build dikes to contain dredged material.

Clark Hill Dam, Savannah District, has a generating capacity of 280,000 kilowatts.

The Corps is involved in two major cooperative programs: the National Program of Inspection of Non-Federal Dams and EPA Construction Grants Program. Is this team work approach working?

Well yes, of course we work with other agencies on everything we do. In the EPA grants program our two agencies are working together, using Corps talents in construction management and EPA grants authority, to provide the people water quality and pollution control structures. It seems to be working quite well. We have written a new agreement with EPA which will give us more authority than in the past to manage construction, but it's still their program. I'm sure of one thing, it's certainly paid for itself and the public is getting better facilities now that the Corps is involved. We're a lot more confident that the money is being spent the way it was intended, too. The inspection of non-Federal dams is primarily our program, though we work cooperatively with state agencies. Some states have more capability to do dam inspections than others. The Corps has developed training programs to assist states. There is no other way to go in government except through cooperation between the agencies which have interest and responsibility. If we've learned one thing in the last ten years it is that no agency can, by its own drive, push a project through the system.

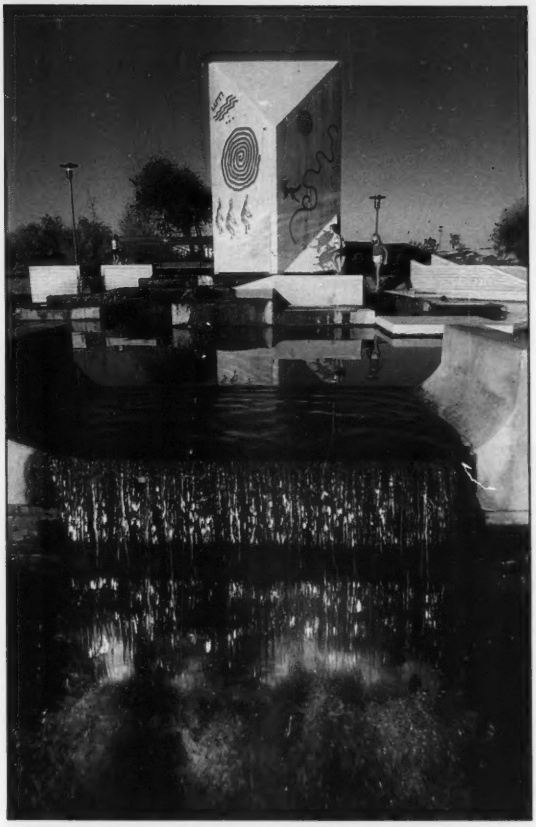
What about the Corps overseas activities? Do they detract from our domestic programs? Are they really an asset to the nation and the Corps?

Yes, they are. We wouldn't be there if they weren't. We participate only at the State Department's request, and every place we've been we have made friends for the Corps and the nation. Our involvement and presence often serve to reduce tension. In our arena we've improved our ability to do business. Benefits come to us because overseas activities have allowed us to keep some of our talents sharp. We've learned a great deal. In addition, during a period of a somewhat diminished public works program here in the United States, overseas activities have assisted us in keeping our work force stabilized. We attract better young professionals to the Corps by the very fact we do the overseas work. We are in tough competition for the best talent, and our work in the Mideast, Israel, and China is a drawing card. This is a hard point to sell though; I'm chastised often by Congress because they fear the foreign program is detracting from the continental one. Really, though, there is very little conflict between use of our manpower domestically and overseas. When we take people out of jobs in the United States and send them overseas, there is some small, short-term adverse effect on the place they leave. But they come back, armed with new engineering experience and insight. So if you can exclude the initial adverse impact, in the long run the overseas program is good for us and for the nation.

I see that conservation will be in our future. And we will probably see some changes in our navigation programs and some increase in hydropower production. It's likely that we will be given an expanded mission in the area of water supply. Do you see other changes in the 80s?

The major change I expect in the Corps in the near future is improved planning of our operations and maintenance work. We plan for water resources development on a regional and even a national basis—assessing present and future needs, costs, benefits, and alternatives. Now we need to begin planning more carefully for the operation and maintenance of our established program. Planning for O&M we call it. Half of the money appropriated to the Corps each year is used for O&M, which covers managing recreation sites, dredging rivers, disaster recoveries and many other things.

Our planning needs to be broken down into our day to day business of cutting grass and painting and our long-term maintenance—major repairs to buildings, locks and dams, replacement of generators. Our long-term maintenance costs can be forecast and need to be planned.



McDowell Exhibit Plaza at Scottsdale, Arizona is part of the Indian Bend Greenbelt floodway. The floodway provides open space for recreation in non-flood times.

An important part of our O&M is our recreation program. It involves both short and long-term maintenance planning as well as planning for activities. This program has been expanding rapidly in recent years. We now host over 400 million visits each year at our projects and we expect that number to grow in the future. The expansion is partly due to the energy crunch—many Corps lakes are located in areas of high population density—and partly due to our increased awareness of public needs. We now provide more facilities, and ones which are more diversified, at our projects than ever before. The atmosphere is a reflection of our new management policies. The managers we now put in charge are people who know how to deal with the public. Some of them are Corps-trained, either at our new facility at Huntsville Division or through a Huntsville-monitored University program. Years ago, we weren't so sophisticated. If our construction engineer was nearing retirement we'd say "Well, look Joe, why don't you just stay here and run the project? You built it so you know how it works." He did know how it worked and he could keep it working, but he wasn't necessarily good at dealing with visitors. Our managers are a different sort today; they are skilled at working with people.

Don't our managers have to be pretty well versed in the field of wildlife management?

Yes, We have developed reservoir management plans aimed at maintaining the balance between use of the land for recreation and preservation of land for wildlife. This is an area in which we have done a great deal of planning and have asked the help of other agencies and the general public. We have not solved all our problems. We still have things to learn about habitat needs of some wildlife species. And, we are still negotiating to insure public access to Corps land in some projects. There are other management problems, but viewed as a whole, we have a recreation/resource management program of which we can be proud.

We've built quite a few visitor's centers recently, haven't we? I'm sure these enhance our ability to greet the public.

Yes. I am very pleased with our visitor information facilities. We have regional facilities located near population centers which present regional and Corps history, depict local archaeological and wildlife features, and show locations of projects in the area. We also have smaller centers for individual projects which explain the project and provide the visitors with information about the recreation facilities available for use.

We have a rather large emergency operations function too. Is this function considered Corps operations and maintenance work, or is our work now directed by the new Federal Emergency Management Agency . . . FEMA?

Well, it's a little of both. We don't always work through FEMA. If there is a flood, I have the authority as Chief of Engineers to direct our people to fight it. We don't have to wait for anyone. In fact, the Division Engineer in charge in the area of flooding has the authority. We can divert funds from other public works projects and then later go to Congress to request their replacement. Once the flood is over, if there has been a lot of damage, the governor can ask

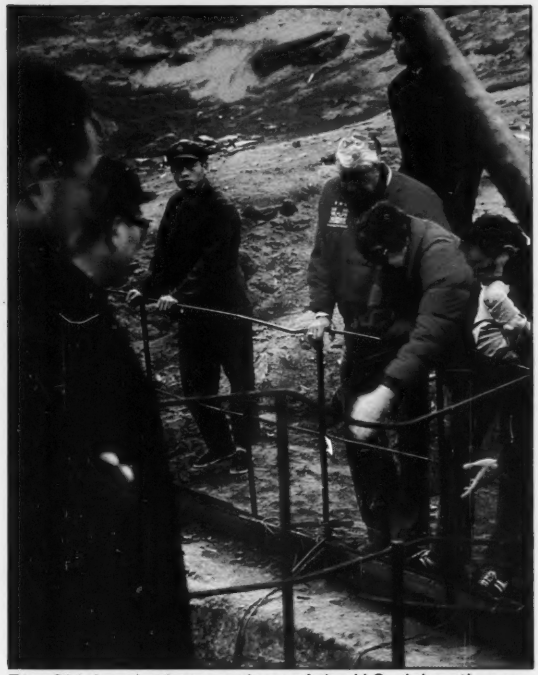
Dredged material provides habitat for Royal and Sandwich tern colony, Cape Fear River, North Carolina.

the President to declare the area to be a national disaster. If the President does so, the director of FEMA has the responsibility to provide whatever relief is needed. If the work requires engineers, FEMA will pay us to do it. So the distinction is whether the emergency is declared to be a national disaster by the President.

Our emergency work is not only with flood problems but also with tornadoes, hurricanes, blizzards—and even volcanic eruptions. We enjoy a fine reputation for efficiency and responsiveness. Apart from money funded by FEMA, the Corps spends about $44 million annually on disaster relief. The year we had Agnes we spent $80 million. This year, with Frederic, flooding in California, and Mt. St. Helens we expect to spend over $250 million.

It is our emergency operations functions which would most closely align with our mobilization assignments in case of war, is it not?

That's true. In the final analysis the Corps of Engineers is an Army unit which must support the total Army during wartime. Our work during national disasters keeps us in training. We are very serious about our mobilization mission and are right now evaluating our capabilities. If we are ever asked to mobilize, we want to be ready.



The Chief and other members of the U.S. delegation on a recent tour of China.

We've talked about the Corps program as it stands today, how it got there, and how it might look in the future. But, to sum up, if I held you to one word could you find one which would characterize the Corps during your term as its Chief?

If I can use just one word, it will have to be "survival." That was the critical challenge. President Carter announced during his campaign that he was going to re-orient the water resources program. He specifically mentioned the Corps of Engineers. After his inauguration he developed a list of projects which he wanted to discontinue—the famous "hit list" of early 1977. At the same time the President appointed a group to analyze the organization of the Executive Branch to propose improvements in several areas, including water resource management. I felt that the future of the Corps of Engineers in water resource management was in jeopardy. If we were to survive as an institution, we would have to prove our worth as the nation's finest engineering and construction management organization. This challenge caused us to evaluate ourselves carefully to find and eliminate our weaknesses and to capitalize on opportunities for strengthening our base and our performance. Ninety eight percent of our projects passed the President's project review. And because of conscientious and objective work in programs such as dam inspection, regulation of wetlands, and others, we were able to convince Administration leaders that the Corps not only should remain in the water resource business but should be given greater responsibilities. So—the bulk of my tenure as Chief of Engineers has to be identified with all of those things related to "staying-in-business."

General Morris, you are retiring now after a full career with the Corps of Engineers climaxing with your assignment as its Chief. How do you feel about your years with the Corps?

I've loved every minute of it. The Corps' work in water resources development is vital to the nation—to its economy and its security. We can be justifiably proud of our past performance and with the National Waterways Study and other important planning studies, the Corps will go on to do even better work. But, you know, the Corps alone can't be fully responsible for developing and managing the nation's water resources, just as we can't take full credit for our accomplishments. In the final analysis, we take our orders from and set our course according to the public we serve. I've thoroughly enjoyed working with the public and with Corps people—managers and laborers alike. I'm sure the Corps will continue to have an important role to play in the development of water resources in the United States and in support of the total Army. ■

Exotic Fish: Environ

by Walter R. Courtenay, Jr.

Oscars, black acaras and algae-eating armored catfishes from South America; Mozambique mouth brooders, spotted tilapia and jewelfish from Africa; Jack Dempseys, firemouth cichlids, platyfishes, swordtails and pike killifish from Central America. Does this sound like a series of labels on fish tanks in a pet shop? Perhaps, but it is also a partial listing of the introduced, reproducing exotic fishes found in canals, ponds and lakes near Miami in southern Florida. These fishes represent only 11 species of the 20 exotic fishes established in Florida and the 36 species established in all of North America north of the Rio Grande River.

Many Americans interpret the word exotic as meaning strangely beautiful and, indeed, several of these introduced fishes can be so described. But the first definition of exotic means **foreign** or **imported.** Exotic fishes, as used here, means fishes that are not native to North America.

Man has had a long history of introducing exotic plants and animals and of transplanting organisms that are native to one part of a continent or nation into another area within the same continental or governmental boundaries where the species are not native. For example, most of our agricultural crop and farm animals are of foreign origin. But there are important differences between importing and introducing something such as vegetables, fruits and domesticated livestock that require care and husbandry to exist in a new environment, and importing and introducing something from the wild into new ecosystems. In the latter case, the only human activities required are importation and one or more subsequent releases.

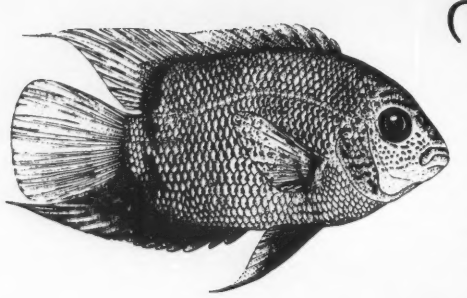
There are other contrasts. Most agricultural stocks are far removed genetically from their ancestors, with varieties and hybrids having been selected by man for maximum productivity. Here, in their host environment, every effort is made to keep them healthy and free from diseases and parasites. Their habitat is continually cared for so that competitors or predators are kept under control. This is not to say, however, that we have been so careful as to avoid introducing exotic pests. The house mouse, the Norway and black rats, house sparrow, starling, Dutch elm disease, Japanese beetle and a host of other unwanted alien species are costing us millions of dollars per year in control programs. (Persons interested in examining the history of these introduced pests in more detail are referred to Charles S. Elton's book, **The Ecology of Invasions by Plants and Animals,** published in 1958 by Chapman and Hall, London and George Laycock's book, **Alien Animals,** published in 1966 by The Natural History Press, Garden City, New York.)

Two Albino Walking catfish photographed in 1968. (Vernon Ogilvie)

Dr. Courtenay is a Professor of Zoology at Florida Atlantic University, Boca Raton, Florida 32306.

Mental Roulette

The dark color phase of the Walking catfish (Photos by the author unless otherwise specified.)



When a wild-caught exotic species is introduced into a new environment, an organism is taken from a highly-complicated and typically poorly-understood native environment in which that species evolved and where its populations were kept in check by a variety of other species that evolved with it. In its new environment, there is little likelihood that a totally accurate estimation can be made as to what the newly-released exotic species will do in terms of its feeding, reproductive or behavioral habits. It may be unable to reproduce or compete, in which case the exotic will not become established. Conversely, it may reproduce and, finding many if not most of the constraints, competitors, diseases and predators that kept the species under control in its native habitats now absent, begin explosive population growth with broader reproductive, feeding and behavioral strategies. Most freshwater fishes have a far greater array of talents to adapt in new environments than one typically would expect and this demands strong caution concerning the release of exotic fishes in our waters.

How did these alien fishes get into our waters and where did they come from? Let's start the answer with a brief history of fish introductions in the U.S. The first introduction was that of the goldfish, native to southeast Asia and cultured for centuries there and in Europe, beginning in the late 1600s. Prior to World War I, a total of six exotic species had been introduced into American waters: goldfish, common carp, ide, rudd, tench and brown trout. These were all purposeful introductions, apparently made to keep European immigrants happy that some fishes from their homeland, often used for food there, were here also. Of these fishes, only the goldfish and carp are native to Asia, but both species had been cultured in Europe for centuries; all of the others are European natives. I hasten to add that of these early introductions — all made without any testing as to their impact on native fishes or their habitats — the brown trout is the **only** example of a successful introduction. By successful, I mean an introduction that has had minimal impact on native fishes and has proved to be useful to American citizens. Goldfish and common carp are largely regarded as trash fish and (often for common carp) as pests. Little is known of the biology of the tench in the U.S. and the ide and rudd have not spread from their original sites of introduction.

Between World War I and II, three more exotic fishes were introduced: the bitterling from Europe and the medaka and oriental

weatherfish from Asia. All are aquarium species and two appear to have been released as unwanted pets. Since World War II, however, an additional 27 exotic fishes have become part of our fish fauna, and most of these were introduced since the 1950s. Our research has identified another 50 exotic fish species in U.S. waters that are not established; these include fishes that were purposefully or accidentally released and a few that had become established and later died out or were exterminated on purpose.

Of the established species, governmental agencies were involved in release programs for at least 12. Governmental agencies in the U.S. and Canada also appear to have been responsible for the introduction of at least 12 additional species that failed to establish in North America.

Our research has also indicated strongly that the aquarium fish culture industry, largely centered in Florida and southern California and, to a far lesser degree, aquarium fish hobbyists releasing unwanted pet fishes, have been the sources for as many as 24 of the established species. In California, two western Pacific gobies apparently became injected into the California fish fauna as the result of transoceanic ships releasing ballast water picked up in foreign waters containing these fishes. These same two species were recently introduced into Australia in the same manner. Of the total of at least 36 species of exotic fishes now established in U.S. waters, there are 12 from Central America, 3 from South America, 5 from Europe, 6 from Africa, and 10 from Asia.

A South American Suckermouth catfish (Shafland)

Fish culture operations almost invariably lead to releases or escapes. This is why many fishes, cultured in the U.S. for sale in the aquarium fish hobby trade, are now part of our fish fauna, particularly in Florida and southern California. This is also the reason that the Asiatic silver carp, under culture in Arkansas for use as a potential future control of phytoplankton blooms, has now been caught in the wild on at least three occasions.

There are, however, prerequisites for exotic fishes becoming established from such facilities: (1) there must be acceptable habitats (canals, rivers, ponds, lakes, etc.) with suitable environmental acceptance potential (proper temperature regimes and pH levels, few predators, etc.) and (2) escape routes (flooding, unscreened effluent pipes or intentional dumping of unwanted or, in some cases, illegally-held stocks).

It is difficult to determine whether releases from such facilities are accidental or intentional, but one thing is clear: fishes introduced in such a manner have **never** been screened or studied as to their real or potential impact on native fishes or their habitats.

An adult Red Belly piranha.

In Florida, aquarium hobbyists have played only a minor role in releasing exotic fishes. We have found two populations of South American armored catfishes near Miami that we suspect were aquarium releases. Isolated populations of the Central and South American guppy and the southeast Asian Siamese fightingfish near Boca Raton and Deerfield Beach, respectively, were aquarium releases that became established but failed to survive the cold weather of early 1977. The pond in front of the Civic Center at Satellite Beach, near Cape Canaveral, appears to be a favorite dumping place for local aquarists that has led to the establishment nearby of the Central American Jack Dempsey and southern platyfish, the African blackchin tilapia and probably the Mozambique tilapia, and the oscar from South America.

Yellow Belly cichlid in a rock pit south of Fort Lauderdale. (Dial)

That people dump unwanted pet fishes elsewhere in the U.S. is demonstrated by the finding of specimens of the Asiatic giant gourami in Pennsylvania, a South American smooth armored catfish in New York, the Asiatic giant snakehead in Maine and Rhode Island, the South American pacu in California and Ohio and related piranhas in

Florida Game and Freshwater Fish Commission members electro-shocking exotic fish.

A Black acara from a South Miami canal.

A young Jack Dempsey from a South Miami canal.

Michigan, Ohio and Pennsylvania, the oscar in Massachusetts, Mississippi, Pennsylvania and Rhode Island and the Asiatic walking catfish in California, Georgia, Massachusetts and Nevada. These are but a few examples of exotic fishes released in areas where, for the most part, their establishment is unlikely. Other states have not been so fortunate.

Releases of exotic aquarium fishes in the southwestern states have proven in several cases to be a major factor in the decline of certain endemic fishes to the point of extermination. For example, the Central American convict cichlid, along with other exotic and transplanted native fishes, apparently caused the decline and extermination of the native speckled dace in Nevada. The last remaining population of the native Pahrump killifish in Pahrump Valley, Nevada, was sharply reduced in numbers by the introduced goldfish. The Central American shortfin molly caused the original decline of a population of the endangered native Moapa dace at some localities in Nevada; in combination with the transplanted largemouth bass, the molly brought about the decline and extinction of a population of the White River killifish. Clearly, releasing exotic fishes or transplanting native fishes into areas having impoverished fish faunas, often with a high degree of endemism, is inviting the decline and extinction of many native species.

Tourist attractions and amusement parks, particulary in Florida, sometimes stock exotic fishes. One tourist attraction south of Miami introduced a species of white piranha in an isolated sinkhole; that species became established and existed there for more than a dozen years before it was found and eradicated by the Florida Game and Fresh Water Fish Commission. In April 1980, a dense, established population of the Central American salvini cichlid was found in a deep borrow pit on the site of a former amusement park south of Fort Lauderdale. There is some indication that this aggressive species may have been transplanted to ponds in western Fort Lauderdale where it may escape into the network of canals there and expand its range.

The availability of exotic fishes in open waters or even in unsecured experimental areas often invites persons to move them to other loca-

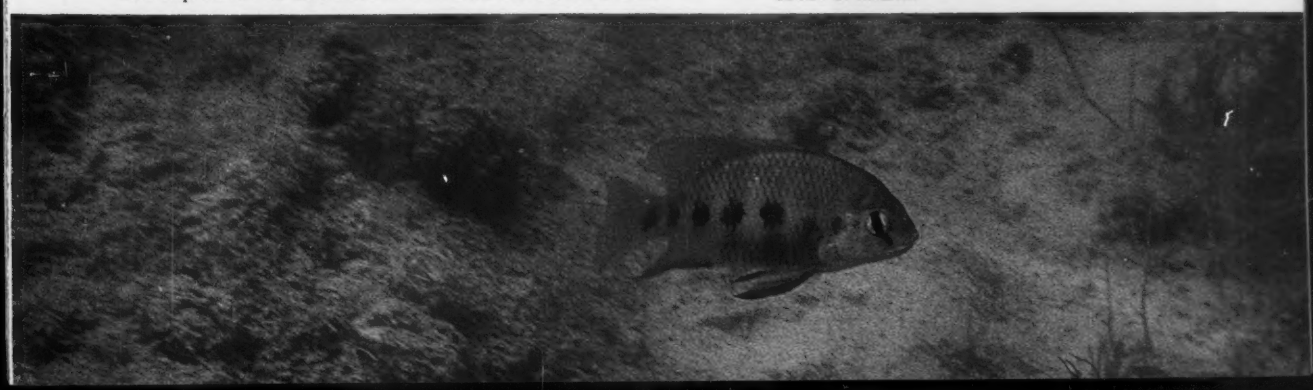
tions. This was a major cause of the rapid dispersal of the African blue tilapia, brought to Florida in 1961 for experimental purposes, throughout most of the western and central peninsula. In hopes of reducing huge populations of blue tilapia in many central Florida lakes, the Florida Game and Fresh Water Fish Commission allowed commercial fishing for this species in 1973. There is some indication that persons are now moving the blue tilapia into lakes where this species has not been present for the purpose of creating a commercial fishery for themselves. There is no environmental concern shown by such activities, especially since this exotic fish has been shown to represent less than one percent of the total fish biomass (present by weight of all fish species present) in one central Florida lake and better than 93 percent four years later!

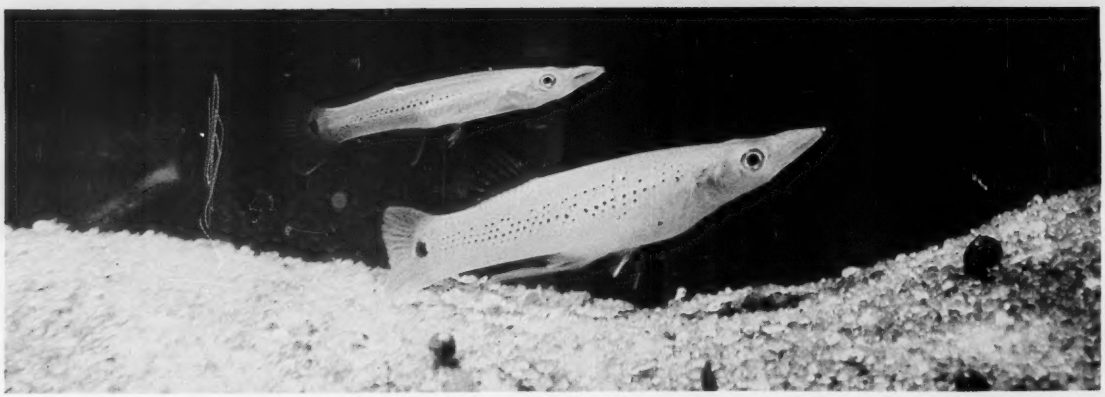
The finding of a single adult walking catfish in a small freshwater lake on Big Pine Key, Florida Keys, may have been an aquarium release or a mischievous prank with a specimen taken from open water on the mainland; there is no likelihood that this fish could have gotten there on its own because it would have had to travel through waters loaded with large predators. This species is tolerant of brackish and salt water. The explosive spread of the walking catfish on the mainland, however, is not so surprising. This airbreathing alien, capable of overland migrations — including around salinity and flood control dams — has dispersed throughout the freshwaters of the southern half of peninsular Florida since its first release in the mid-1960s. It is now established in the headwaters of the St. Johns River, a northward flowing river that originates in marshes west of Fort Pierce and Vero Beach and empties into the Atlantic Ocean at Jacksonville.

Reports in newspapers in the early 1970s of thousands of walking catfish having been killed by cold winter temperatures in southern Florida were true; predictions by newspaper reporters that this species was doomed in Florida were incorrect. There have been "cold kills" since then, particularly in early 1977, but it is apparent that it is the cold-resistant segments of the populations that are surviving, swimming and crawling northward. The supreme test as to how far north they will go, at least in Florida, is now underway in the St. Johns River.

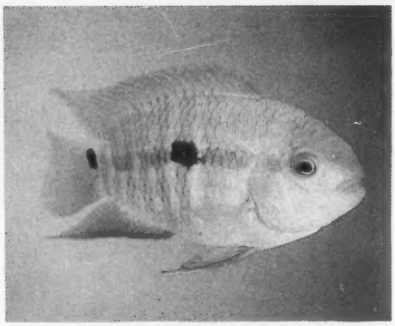
Purposeful introductions are typically conducted by governmental agencies. Such introductions are often massive, thereby greatly increasing the chances for establishment. This was the case in the introductions of both the common carp and brown trout in the late 1800s. Neither of these exotics was examined for potential adverse impacts prior to their releases. Since the 1950s, interest in using exotic fishes to control certain pest species biologically has grown. In Arizona and California, at least two species of African tilapias were introduced for algal control, although neither species is strictly herbivorous — except under experimental conditions where its only or predominant food source is algae. There have been significant population increases of these tilapias at several localities, and these are reasons for concern and caution in using tilapias as biological controls. Accidentally introduced tilapias in some locations in Florida have undergone population explosions so extensive as to crowd out native fishes.

An adult Spotted tilapia in a canal south of Miami.

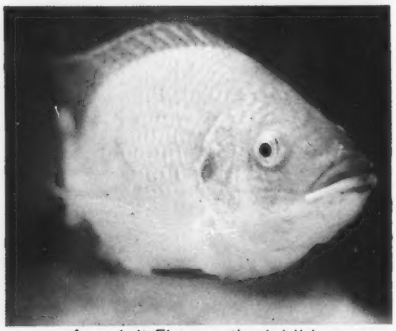




A pair of killifish.



A Black acara in a tank. (Paul Shafland)



An adult Firemouth cichlid (Shafland)

A pair of Blackchin tilapia. (Shafland)

The use of the Asiatic grass carp, often called white Amur by its proponents, has been a subject of controversy among many ichthyologists, fishery biologists and aquatic plant control experts since the 1960s in the U.S. Proponents claimed that the spawning requirements of this exotic in its native habitat were so specific as to preclude reproduction in the U.S., thus suggesting a biological control agent whose populations could be controlled by man. Others, however, warned that its native habitat is duplicated easily in several parts of the U.S. and that natural reproduction was not only likely but was to be expected.

Since over-control of rooted aquatic plants reduces vegetation that is important as cover for the young of many native fishes and their food organisms, overstocking or natural reproduction by grass carp was to be avoided. Overstocking of this exotic in two central Florida lakes resulted in over-control of aquatic and emergent vegetation to the point that a 1979 report by the Florida Department of Natural Resources recommended that "grass carp not be used in water bodies where the primary concern is fisheries or wildlife habitat." Moreover, widespread and frequent stockings of grass carp in Arkansas have apparently led to the establishment of a reproducing population of this exotic in the Mississippi River. In my opinion, the intentional introductions of grass carp in Arkansas, Alabama and Mississippi amounted to using open waters as the testing laboratory, a practice that has a long and dangerous history.

Finally, I do not condemn all exotic fishes as potentially harmful. Also, while I could argue against any future introductions of exotic fishes, I know that there will be future releases. Technology to prevent future accidental escapes from culture facilities exists, and education of aquarium fish hobbyists, probably through aquarium magazines and pet shops, should slow releases of pet fishes into open waters. It is future purposeful or intentional releases that must receive far more scrutiny than has occurred in the past. The biology of such candidate exotic fishes for introduction must be examined in detail where the species exists naturally and where it may have been introduced elsewhere before importation for experimentation in escape-proof facilities here is permitted. The agency (or agencies) conducting experimentation on potential impacts should not have the authority to conduct releases until their data have been reviewed and approved by outside specialists.

Otherwise, introductions will continue to be nothing more than a game of environmental roulette where the stakes are often high and the chances of winning are low — as our history with exotic fishes demonstrates. ■

ESTABLISHED EXOTIC FISHES IN NORTH AMERICA—1980

Species with expanding populations

Acanthogobius flavimanus	Yellowfin goby	CA*
Astronotus ocellatus	Oscar	FL*
Carassius auratus	Goldfish	Most states*, three provinces
Cichlasoma bimaculatum	Black acara	FL*
Cichlasoma meeki	Firemouth cichlid	FL*
Cichlasoma nigrofasciatum	Convict cichlid	AT, AZ?, NV*
Cichlasoma octofasciatum	Jack Dempsey	FL*
Clarias betrachus	Walking catfish	FL*
Ctenopharyngodon idella	Grass carp	AR*, LA*, MS*, TN* and other states
Hemichromis bimaculatus	Jewelfish	FL*
Poecilia "sphenops complex"	Shortfin molly	NV*
Tilapia aurea	Blue tilapia	CA*, FL*, GA?, OK, TX*
Tilapia mariae	Spotted tilapia	FL*
Tilapia mossambia	Mozambique tilapia	AZ?, CA*, TX?

Species with localized distributions (= not expanding)

Belonesox belizanus	Pike killifish	FL
Cichlasoma salvini	Yellowbelly cichlid	FL
Cichlasoma severum	Banded cichlid	NV?
Hypostomus sp.	Suckermouth catfish	FL[1]
Leuciscus idus	Ide	CT, MD?, NY?, PA?, VA?
Misgurnus anguillicaudatus	Oriental weatherfish	CA, MI
Oryzias latipes	Medaka	NY
Tilapia melanotheron	Blackchin tilapia	FL
Tinca tinca	Tench	BC, CA, CO, CT, ID, NM, OR, WA
Trichopsis vittata	Croaking gourami	FL
Tridentiger trigonocephalus	Chameleon goby	Ca
Xiphophorus helleri	Green swordtail	AT, FL, MT
Xiphophorus maculatus	Southern platyfish	FL, NV
Xiphophorus variatus	Variable platyfish	FL, MT

Species with apparent broad and stable distributional limits

Cyprinus carpio	Common carp	Most states, several provinces
Salmo trutta	Brown trout	Most states, several provinces

Insufficient information available to determine populational status

Hypomesus nipponensis	Wakasagi	Ca
Hypostomus spp.	Suckermouth catfishes	CA, FL, TX, NV
Poecilia reticulata	Guppy	AT, AZ, CA?, FL, NV
Poeciliopsis gracilis	Porthole livebearer	CA
Rhodeus sericeus	Bitterling	NY
Scardinius erythrophthalmus	Rudd	NJ?, NY, WI?

* indicates where populations are expanding or can be expected to expand.
? indicates current status unknown (= still established?)
[1] refers to population of armored catfish in Six Mile Creek, Hillsborough County, FL; status of populations in Dade County, FL undetermined.

ASIATIC CLAM INVASION

Causes and Effects

by Donald S. Cherry;
John Cairns, Jr.,
and Robert L. Graney

In an earlier article in *Water Spectrum* (Fall 1979), an overview of energy production research was presented with an emphasis upon thermal discharges. Besides heated water, intermittent chlorination practices (periodic treatment with chlorine for antifouling purposes), and coal ash effluent (ash after coal is burned) with associated heavy metal and potentially toxic element consequences, were reviewed. Various experimental approaches for evaluating the ecological effects upon aquatic biota were presented, including the use of a field laboratory and artificial stream system located at the Glen Lyn powerplant in southwestern Virginia.

One area of concern that was briefly mentioned included the use of

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intermittent chlorination for control of biofouling organisms. The general forms of fouling organisms include deposition of bacteria and fungal populations in condenser tubes, which reduce the inner tube diameter and efficiency of waste heat transfer. The general procedure of releasing specific chlorine doses three times daily for 30-minute intervals has proven to be an effective antifouling procedure for most organisms.

Recently, however, the introduction and subsequent invasion of the Asiatic clam (*Corbicula fluminea*) has offered a new problem of infestation in powerplant intake systems that conventional intermittent chlorination procedures may not resolve. Characteristics of the Asiatic clam include a eurythermal nature (resistance to a wide range of temperature changes), behavior responses to chlorination (tightly closing their shells during chlorine doses), high reproductive rates, general resistance to water quality fluctuations, and an ability to adapt to a variety of substrates (gravel to clay). The dynamics of population increases of this organism are discussed in a case history at the Glen Lyn plant where no clams were found before 1975, followed by a rapid density proliferation in subsequent years. Potential control measures are described from recent laboratory and artificial stream bioassay or toxicity studies with recommendations for future consequences to the powerplant industry.

ECONOMIC PROBLEMS

Once the Asiatic clam invades an aquatic environment, the general result is an unusually dramatic increase in population density. The abnormal proliferation of numbers is attributed to the high reproductive capacity, precocious development (these clams possess both male and female reproductive systems that maximize the chance of fertilization of eggs by sperm), adaptability to relatively wide ranges in water quality and sediment characteristics, and resistance to biocidal control measures (to be discussed in detail later) and burrowing into sediments.

Several major industries that utilize raw water supplies for cooling and other purposes have been adversely affected by clam invasion. One of the first major cases occurred in the past few decades on the west coast in agricultural industries. Following two to three years of successful colonization of irrigation ditches, deposition of live clams, dead shells, and resultant debris amounted to two to three feet of clogged canals. The result was a drastically shortened longevity of irrigated canals without expensive, unplanned dredging procedures.

Production problems from clam infestation have been encountered by the sand and gravel industry. Clam movement in sand and gravel deposits may cause voids in concrete aggregates during the pouring process, or the hollow shells may contribute to structural weaknesses. Mechanical separation of clams from gravel has been an unexpected, costly and time-consuming process.

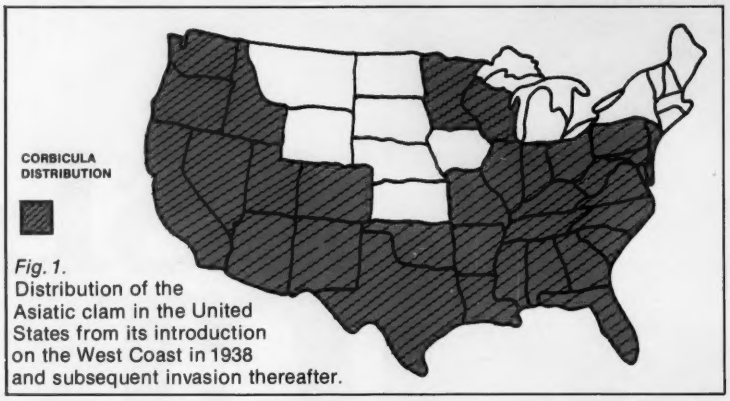

Fig. 1.
Distribution of the Asiatic clam in the United States from its introduction on the West Coast in 1938 and subsequent invasion thereafter.

Biofouling in condenser and service water systems of steam electric powerplants has been another major problem associated with the Asiatic clam. Small clams may pass through the rotating screen systems (5/8 inch diameter—which normally filter out most debris from the water intake) and either attach or lodge in the condenser pipes. These pipes serve as the mechanism of heat transfer in condensing steam to water which is then pumped back to the boiler system for reheating into steam for generation of electricity.

Besides clogging, which impedes water flow and reduces the efficiency of heat transfer, the lodging of dead clam shells may eventually erode the copper condenser tubes. This results in the mixing of raw river water with the closed steam generating system of powerplant energy generating water used for electrical production. When this problem is found, unscheduled maintenance is required in replacing defective pipes, and the loss of power generation time becomes a problem of energy production in addition to the repair cost.

At the Savannah River Project near Aiken, South Carolina, another unique situation is cited. Clam proliferation in large, concrete, water storage basins used as small reservoirs (capacity of 8 million gallons each) from which cooling water from the Savannah River is pumped into the existing powerplants, has presented uncalculated nuisance problems. Periodic (every 10–11 months) excavation practices of clams from these basins has been employed to effectively reduce clogging of the heat exchangers in the energy production plants at SRP. The diameter of the heat exchange pipes are considerably smaller than those of traditional powerplant condenser pipes, which made them more prone to clogging activity by *Corbicula*. Since no biocidal treatment adequately prevented fouling, the only recourse was to reduce the density of the clam population in the water storage basins which had accumulated to three to four feet by 1975. The potential filling process by *Corbicula* occurred rapidly since the organism was first sampled in the Savannah River at Augusta, Georgia, in 1973.

INVASION OF U.S. WATERWAYS

The Asiatic clam was first discovered in 1938 on the west coast in the Columbia River, Washington. The organism became well established in most western states

by the late 1940s and was reported to be a nuisance in the California irrigation systems. *Corbicula* invaded the Mississippi and Ohio River drainages by the late 1950s. By 1961, the clams were collected in the Kanawha River at Charleston, West Virginia, probably from propagules originating in the Ohio river. The Asiatic clam was first reported in the Altomaha River, Georgia, in 1970 and reached densities of 10,000/m^2 several years later. To date, *Corbicula* have been found in all southwestern and southeastern states with somewhat limited distribution in the northern areas. (Fig. 1)

GLEN LYN, VIRGINIA INVASION CASE STUDY

Corbicula was not found in the New River at the Glen Lyn plant before 1975. Since then, clam densities were measured from approximately 20 to 30/m^2 in October, 1976. It is believed that the organism originated from the Kanawha River which is in the northern extension of the New River in West Virginia and was calculated to have a migratory rate of approximately 9 miles per year to Glen Lyn. Clams were not found in areas upstream from the powerplant at this time, and the mechanism of clam migration over rapids and through the Bluestone Reservoir in West Virginia is not known. Mechanisms of clam invasion upstream may be due to fishing activities (dumping bait buckets containing clams or clam larvae from one fishing area of the river to another), waterfowl movement (clams or larvae adhering to mud deposits of waterfowl legs), or from the release of live specimens sold to fish hobbyists and shipped around the country.

After the initial colonization process in the New River at Glen Lyn in the fall of 1976, clam densities proliferated heavily during the next two years. Densities in the heated discharge of the plant reached approximately 11,500/m^2 by February 1978 with numbers in unheated regions being as high as 2,200/m^2 by November 1978. Proliferation of clam densities was directly attributed to the effects of the thermal discharge, which served as a source of thermal enrichment. (Fig. 2)

It was evident that after the initial establishment had occurred, unseasonably cold winter temperatures (2 – 0C) in 1977 annihilated *Corbicula* in unheated regions. Clams in the heated water were protected by temperatures that were several degrees above freezing. However, clams safely residing in the heated discharge successfully reinvaded unheated portions of the New River during the subsequent spring and warmer seasons. Clam densities were always higher in the heated discharge thereafter, and while the winter of 1978 had milder temperature conditions, *Corbicula* increased to greater densities in both heated and uninfluenced areas of the New River around the Glen Lyn plant.

Additional evidence was found to support the position that the heated discharge served as an agent of thermal enrichment for the Asiatic clam. When water conditions were unusually severe, cold water conditions decimated clam populations in unheated regions around the powerplant, but with the next spring, new larval recruits would reinvade these areas. The composition of size classes would support this viewpoint. (Fig. 3) Note that in the thermal effluent, a greater density of clams (different sizes of shell lengths) was found between 1976 and 1978. These sizes represented 1 to 3-year old individuals, while only first year clams were consistently sampled throughout this period in unheated areas.

Therefore, once clams were able to successfully invade a warmer body of water during spring and summer seasons, the generation of heated water by powerplants served to maintain their existence during the winter. Since powerplants generally maintain continuous operations of energy production during the winter to meet the energy requirements of the public, so were the clam populations similarly maintained. This procedure would allow for successful clam invasion and existence in colder northern water habitats.

Powerplant operations may therefore serve as "harboring sites" or "stepping stones" for successful survival in northern states which have potentially hostile winter climates that generally were thought to inhibit northern invasion. The general health of the clam populations may be reduced since the higher water temperature increases metabolic activity (conversion of food into body requirements) while greater densities enhance competition for food resources. The net result is that average clam weight may be lower than those individuals of lesser densities that inhabit unheated regions. Unfortunately, the thermal enrichment of powerplant effluents apparently may

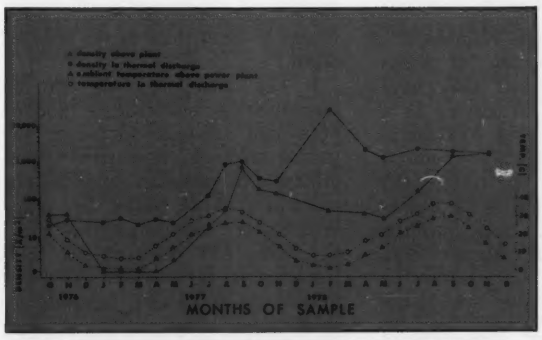

Fig. 2. Density of Asiatic clams sampled in ambient (non-thermally influenced) and heated regions of the New River from the Glen Lyn plant.

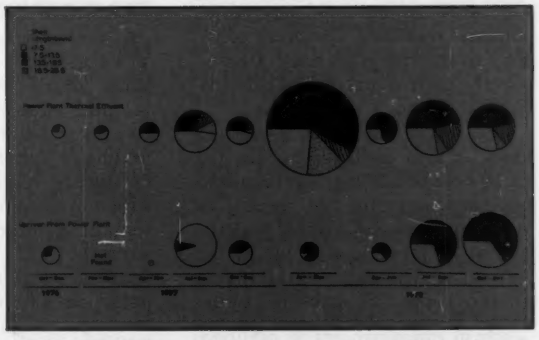

Fig. 3. Comparison of size classes of the Asiatic clam sampled in thermally influenced and unheated regions of the New River.

serve as a prominent tool for propagation into states north of Virginia.

BIOFOULING CONTROL MEASURES PROBLEMS

Discharge permit limitations of chlorine as a biocidal agent by powerplants have been established by the Environmental Protection Agency (EPA) in the formulation of National Pollution Discharge Elimination Systems permits (Public Law 92-500, Section 402 [b] and later amended by the Clean Water Act, Public Law 95-217). At Glen Lyn, the plant is required to adhere to specific chlorine concentrations that are released intermittently (three times per day at approximately 30-minute intervals). These chlorine concentrations (weekly average of 0.2 mg/liter free residual chlorine, one peak dose of 0.5 mg/liter) are not effective in eliminating *Corbicula* from the aquatic system or, perhaps, even from the condenser pipes.

Clams possess the behavioral ability to "clam up" (tightly close their shells) during the potentially hostile 30-minute dosing interval, and then resume normal filtering (feeding) activity thereafter. These organisms have also demonstrated that they can resist continuous chlorine exposures as well. A constant concentration greater than 0.5 mg/liter free residual chlorine (maximum single EPA concentrations during a 30-minute weekly period) was necessary to result in 50 percent mortality of clams exposed *continuously* for 10 days in laboratory toxicity tests. When this single 30-minute environmental dose is compared to 240 hours of continuous exposure in laboratory bioassays, the potential regarding *Corbicula* resistance to chlorine is immense. Consequently, current practices of chlorine biocidal control are ineffective.

The use of copper as a biocidal agent is also inadequate since the LC50 dose of 0.59 mg/liter (continuous exposure for 24 hours in laboratory bioassays) would be detrimental to most aquatic life in the New River. The maximum allowable limits of copper, as established by the EPA in the 1979 Water Quality Criteria, are more than one order of magnitude lower. These data again support the general viewpoint of the resistant quality of the Asiatic clam to changes in water quality and heavy metal stress.

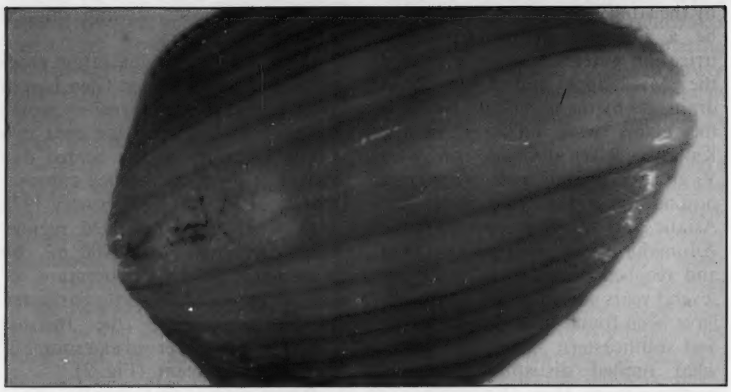

Fig. 4. Gaping activity of the Asiatic clam in which the clam shells are more widely positioned than during filtering activity.

Fig. 5. General siphoning activity with clam movement being facilitated by movement of the muscular foot from the base of the shells into the sediments.

CLAM GAPING

Another behavioral response ("gaping"—opening of shells when overly stressed) may have promise, however, in serving as a control technique. (Fig. 4) General feeding or siphoning activity consists of slightly venting the clam shells with movement occurring by protrusion of a muscular foot into the sediment. (Fig. 5) Abrupt high temperature flexes or exposure to potassium have initiated stress in the form of a gaping response. In laboratory bioassays of continuous chlorine or copper exposure gaping was evident before mortality was observed. Once this behavior occurred, death was measured quickly thereafter. In many cases, *Corbicula* lacked the ability to close their shells—which allowed the inner body organs to be effected by the biocidal agent.

It has been proposed that by manipulating temperature and/or potassium exposure to induce the gaping response, short-term (intermittent) chlorination may induce mortality. Work done by other investigators has shown that short exposures (30 minutes) to high temperatures (greater than 40C) will induce gaping, which, followed by chlorination, may provide a more effective method of control. More research should be carried out to test the merit of these approaches.

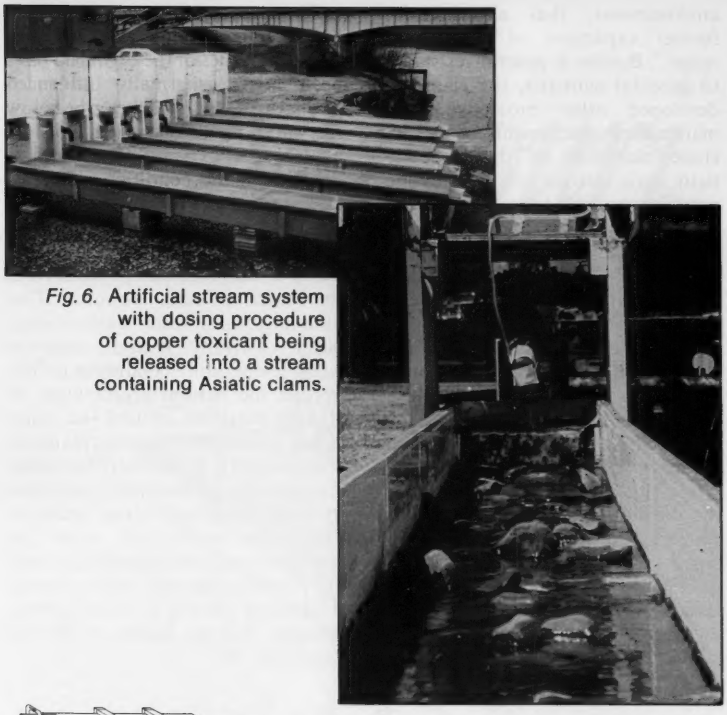

Fig. 6. Artificial stream system with dosing procedure of copper toxicant being released into a stream containing Asiatic clams.

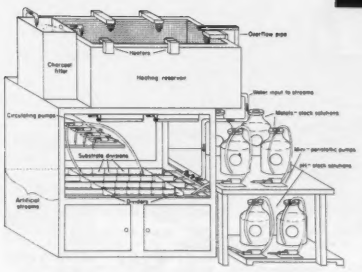

Fig. 7. Laboratory artificial stream system used to test the response of *Corbicula* dosed to heavy metals, pH, and chlorine stress.

CORBICULA UTILIZATION

If the Asiatic clam cannot be irradicated from aquatic systems, then the opposite approach is to harvest or utilize the organism for its calcium and protein content. Suggestions for potential utilization have included use as fish bait, biofilters for organically polluted areas (filters of organic pollutants), bioindicators of heavy metal pollution (metal uptake in tissue may indicate the general metal exposure), aquaculture for poultry and animal feed, and as fertilizer. The high calcium content in the clam shells and protein content within the body tissues or visceral mass may serve as an alternate food supply for poultry now that anchovy fish populations have become scarce in South America. The use of the heated effluent as a tool in thermal aquaculture has been proposed by other investigators. *Corbicula* grow optimally in the heated devices, even when kept in cages.

The use of *Corbicula* as a food source for humans is uncertain in this country, perhaps due to a lack of acceptance in palatibility from its small size, little acclaim for flavor and accepted usage and general regard as a "pest." However, it has been a reliable food source in Asia for years. Unfortunately, its small size (three-year-old specimens are usually less than a 25-cent piece in diameter) may not be an attractive food source even if its food quality and flavor become acceptable in this country.

COMPARING LABORATORY BIOASSAYS TO FIELD SITUATIONS

The acute laboratory bioassay data have not provided useful information that can be directly related to the New River ("real world") situation. One problem in this approach is that laboratory static conditions are carried out in small non-flowing chambers or aquaria that do not "mimic" or relate to actual field conditions. Therefore, when field artificial stream bioassays were used at the powerplant, in which New River water was pumped through artificial streams on a once through basis, the concentrations producing a lethal effect in the laboratory resulted in a no effect response in the aritificial streams. (Fig. 6) Apparently, clams were stressed concurrently from the artificial laboratory conditions as well as from the toxicant exposure. These same concentrations were ineffective in the field streams since the more natural conditions did not contribute to the stress imposed by the toxicant. Unfortunately, field artificial streams have much greater fluctuations in water quality from the natural river system and make predictive estimates difficult.

One way to correct for these difficulties is to develop artificial streams in the laboratory with a flow through procedure that will compare to the rapid water flow in the environment. (Fig. 7) A dosing technique using peristaltic pumps can be used to apply specific dose requirements that may more effectively be used to predict the response to the toxicant without stressful consequences from static water conditions. This procedure is simpler and less expensive to develop than artificial stream systems set up at the plant. This laboratory system can provide information with less natural variability from a nonfluctuating water source of similar chemical quality.

The potential use of clams as a bioindicator of heavy metal stress (degree of metal uptake within body tissue) may provide more reliable information about the potential condition of the organisms in stressed environments. In any case, less variability can result which increases

a potential for predictablity. Once laboratory trends are obtained without the daily fluctuations in water quality that may contribute to the natural variability of the organism (which adds more confusion to the hypothesis being tested), these results may offer new insight for predicting responses in field situations.

After these objectives are met, controlled laboratory alterations can be manipulated to mimic general river ambient fluctuations in order to predict results that occur in the actual riverine environment.

ELEMENTAL UPTAKE BY *CORBICULA*

Due to the propensity or tendency of bivalve mollusks for heavy metal accumulation, many investigators have suggested the use of tissue concentrations as an indicator of metal contamination in the aquatic environment. The reproductive potential of *Corbicula,* cosmopolitan distribution and resistance capabilities make it particularly suitable for this task.

Preliminary laboratory investigations have shown that a postive relationship exists between water concentration and clam metal body burdens (amount of metal incorporated into body tissue from aquatic exposure). As the aquatic heavy metal concentration increases, the degree of uptake or metal accumulation in the visceral mass of *Corbicula* also increases. This is an essential criterion if an organism is to effectively indicate the quantity of metal pollution found in the environment.

SUMMARY

In summary, the potential effects of powerplant discharges upon the Asiatic clam are many, although the actual results are probably minimal. (Fig. 8) Natural predatory interactions may occur from channel and flathead catfish, and from terrestrial predators such as raccons. From the realized, alarming increases in population density and invasion rates throughout most of the country, these effects are probably negligible to the general public.

Ecological effects that are apparent include a thermal enrichment effect whereby *Corbicula* are "housed or protected" in heated, receiving waters, especially in colder, northern environments, thus allowing for further expansion of the "home range." Besides a general resistance to biocidal activities, the clam has developed other protective, self-maintaining mechanisms. These include "clamming up" during potentially toxic intermittent chlorination practices, possible burrowing activity into the sediment or substrate to escape detrimental industrial releases, rapid and efficient reproductive potential, and a general resistance to heavy metal bioaccumulation.

The overall effect upon indigenous mollusks and other benthic (sediment dwelling) populations may result in the competitive exclusion of the other naturally occurring mollusk populations. The effect upon power production may result in unscheduled shutdowns for removal of clams congested in condenser pipes or for repair of these units. These ramifications certainly result in a reduction of economic efficiency to power production. The effects upon other industries (irrigational activities in agriculture) have already been realized.

The impact on most powerplants has been minimal because the major infestation sites of the organism have been in the thermally influenced discharge waters which may be below the pump house operating units (as analyzed at Glen Lyn). Natural winter climatic conditions have retarded the dense accumulation processes of clams from developing in the ambient waters around the intake pump houses located upstream from the heated effluent. However, if an unusually warm winter season should occur, whereby natural, ambient water temperature conditions do not impede the natural proliferation of clam populations around the pump house operations of powerplants in semi-southern to northern habitats, clams may be afforded the opportunity to develop into dense numbers. This consequence will cause an unprecedented and unpredicted fouling problem that will reduce energy production efficiency, which, unfortunately, will be passed on to the consumer. ■

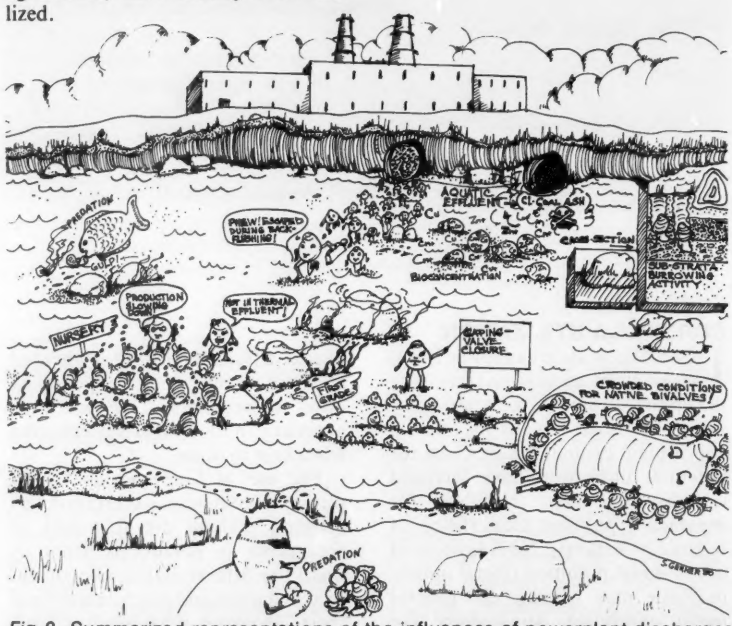

Fig. 8. Summarized representations of the influences of powerplant discharges upon the Asiatic clam in receiving systems of the New River at Glen Lyn.

ACKNOWLEDGEMENTS

The field research carried out at the Glen Lyn plant and the laboratory data generated at Virginia Polytechnic Institute and State University were funded by the United States Department of the Interior, Office of Water Research and Technology (Project B-101-VA), as authorized by the Water Research and Development Act of 1978 (P.L. 95-467).

Missouri River:

Challenge and Opportunity

1979 was a record year for commercial tonnage along the Missouri River, surpassing 3.26 million tons. (C of E Photos)

by Harry A. Dolphin

The love-hate relationship of Man and the Missouri River predates recorded history. It is a vibrant, high intensity relationship that continues to evolve. It is flood and drought, keelboat and stern-wheeler, daring explorer and dedicated homesteader. It is developer and preservationist.

In accommodating to the river, Man has built willow mattresses and earthen dams. He has developed the "308 Reports," Pick-Sloan and, now, the Missouri River Management Board.

She's big, lusty and a brawler, the Missouri River.

Fates of giants have been tied to her. The Missouri's secrets were revealed reluctantly to explorers such as Pere Jacques Marquette and Louis Joliet; Captains Meriwether Lewis and William Clark; Lieutenant Zebulon Pike and Maximilian, Prince of Wien, plus countless others who challenged the river seeking adventure, profit or merely for the zest of the contest.

Western military expeditions traveled her under John C. Fremont, George Armstrong Custer and faceless thousands.

She was highway to adventurers, fur traders, gold seekers, homesteaders — wanderers all. They ranged from the humble,

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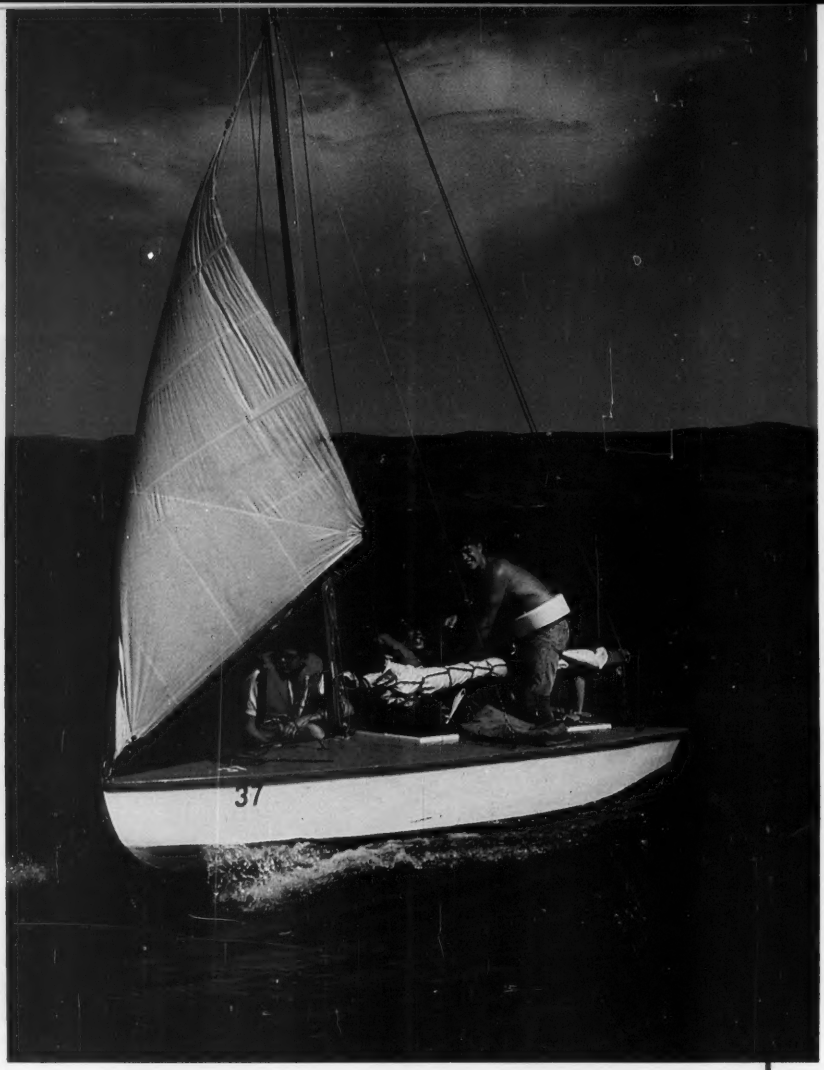


Extending 107 miles upstream from Fort Randall Dam, Lake Francis Case provides ideal sailing conditions for these Sea Scouts.

God-fearing and God-bringing to the hell-for-leather gamblers, fugitives and intemperates such as the legendary Mike Fink (or as he preferred, Miche Phinique).

These incongruous messengers brought civilization — of a sort — to the American West, and most came by way of the Missouri River, the Big Muddy.

The Missouri River basin became part of the United States in the celebrated Louisiana Purchase consummated by President Thomas Jefferson. The big-muscled river drains an area that today includes all or parts of ten states and covers 529 thousand square miles, one-sixth the total area of the 48 contiguous states.

The basin produces two-thirds of the wheat, half the cattle and a quarter of all feed grain produced in the United States — one of the world's true breadbaskets. Almost nine million persons live within the basin, but it was not always so.

TRAVEL ON THE RIVER

Travel was difficult, at times almost impossible for the hardy individualists who penetrated the vastness of the West. Man pitted his muscle against the might of the Missouri in bull-boats, pirogues and canoes. Finally, shortly after the beginning of

the nineteenth century, Lewis and Clark introduced the first keelboat on the Missouri. The keelboat *Discovery* was the largest vessel to travel significant distances on the river up to that time. Primitive? Yes. But far preferable to the alternatives — walking or riding a horse.

Lewis and Clark made the first complete American exploration of the region (1804-06) and described both the geography and people. A comment in their official journals notes that the area was the "richest in beaver and otter than (sic) any country on Earth" — a probable clue to why their expedition was preceded and followed by fur traders.

By 1822 the enterpreneur, Ashley, was advertising for "enterprising young men" to ascend the Missouri after fur. Some who answered were outcasts and had nowhere else to go, while others were driven by the American attitude of "expectant capitalism." To them, risking their lives against tomahawk and trade rifle was a small price to pay.

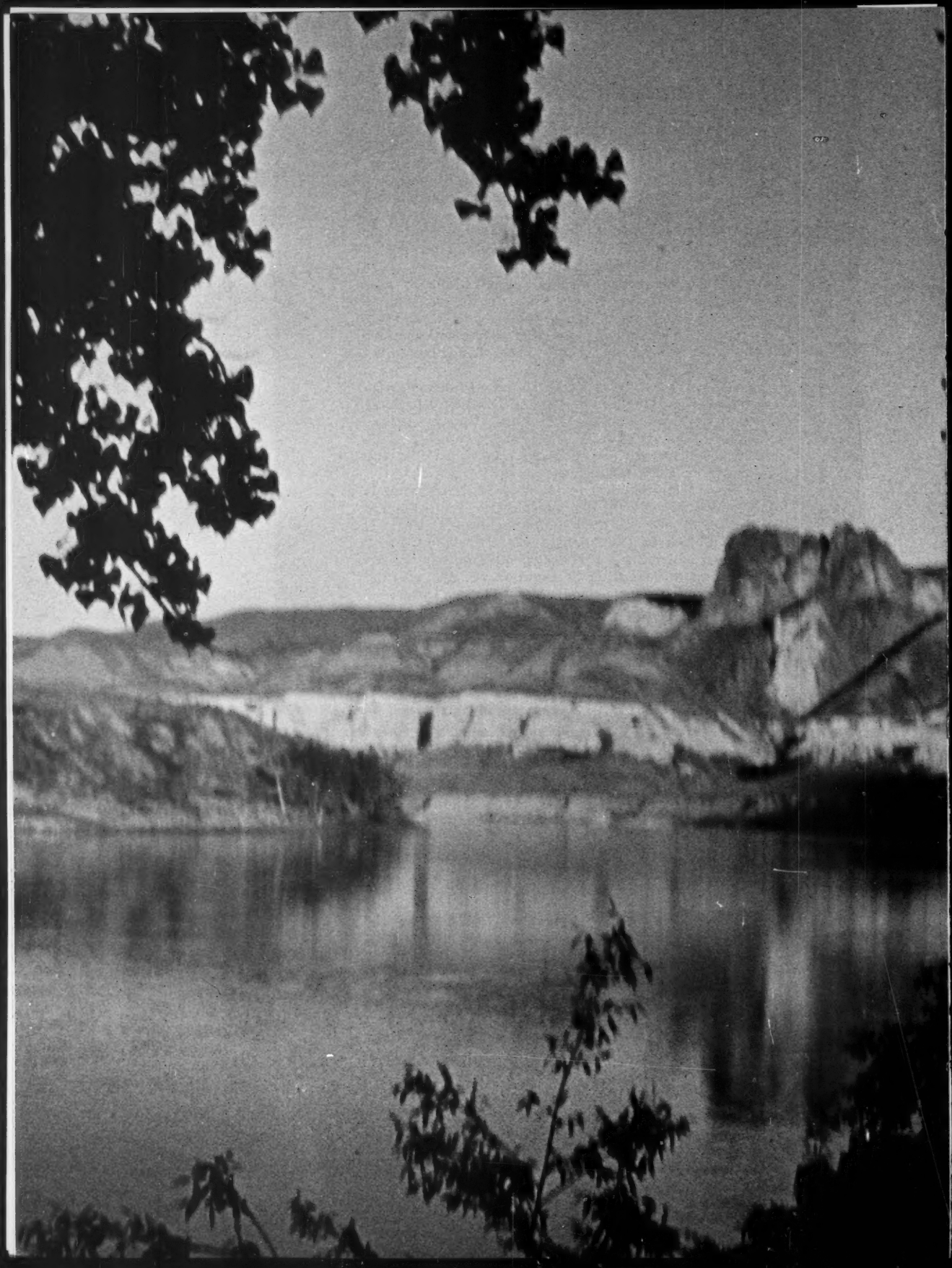
Miners, merchants and farmers who followed them had that dream, too. They, the fur traders and their soldier defenders, brought some measure of their dreams to fruition by application of nineteenth century power technology to the problem of distance of the plains. The time of complete dependence on sturdy legs and strong backs was ending.

The first attempt to shorten river travel times was spring 1819 when five poorly constructed steamboats sallied forth from St. Louis in an abortive effort to reach the Yellowstone River. The expedition, under General Atkinson, was doomed to failure because of the equipment. One vessel exploded and sank while still in view of well-wishers at the St. Louis wharfs. And, only the *Western Engineer,* commanded by Major Stephen Long, struggled upstream as far as Council Bluff above Omaha on the west bank before surrendering to the inevitable. The treacherous currents and twisting channel of the Missouri were too formidable for the fragile craft.

Despite this partial failure, penetration of technological man with his scientific instruments, cannon and — ultimately — his plow meant a great change for the basin.

Steamboats supported the influx of settlers after the Civil War but were unable to penetrate some shallower rivers like the Platte.

Rafting on the lazy Missouri River is a perfect way to pass a sizzling summer day.



So, immigrants completed their journey overland — by foot, wagon and horse — until advent of the railroads.

Still, steamboats like Grant Marsh's *Far West* supported troops in battles such as the historic confrontation at the Little Big Horn. Carrying troops and supplies was a vital function of the steamers and permitted rapid troop movements. Lumber, livestock and hardware also moved on the rivers. Steamboat traffic set new records in the 1870s and Congress appropriated funds for channel improvements. Dikes and bank protection work soon supplemented the earlier snagging efforts accomplished by the Army Corps of Engineers.

However, by 1878 river traffic had declined to a trickle — only 50,000 tons — and river improvements paid for themselves only inasmuch as they protected adjacent land from eroding into the maw of the river.

FLOODING AND PICK-SLOAN

Despite reduced commercial traffic, advantages of continued Corps work on the river were obvious. Flood damages were reduced, and ultimate construction of main stem dams bore promise of greater benefits through still further reduction of flood damages and the addition of hydroelectric power generation for an energy hungry nation.

Severe flooding has challenged Man since he began living along the Missouri River. A major problem arose in 1844 when the river crested from 12 to 17 feet above flood stage. Subsequently, a still worse flood struck in 1881, followed by destructive inundations in 1903, 1904 and 1905. Less critical but still severe floods devastated the valley in prior years.

The cycle of flood and drought continued into the 1920s and eventually Congress took action, commissioning the Army Corps of Engineers through House Document 308 in 1927 to complete a series of reports. The 1245-page "308 Report" for the Missouri basin covered potential power development and irrigation possibilities as well as flood damage prevention and navigation aid.

The reports marked the first time the Federal government considered as feasible massive dams on the main stem of the river which would be multiple purpose projects.

Construction of Fort Peck began in the fall of 1933, a make-work project initiated by the New Deal under President Franklin Delano Roosevelt. In a nation suffering through a historic drought and the Great Depression, the sparsely settled area in eastern Montana became a paradox — a construction project flourishing in a Wild West atmosphere of boom towns teeming with migrant laborers and opportunistic entrepreneurs.

The massive structure (largest hydraulically earth-filled dam in the world) stretched four miles across the valley and towered 275 feet above the river channel. The lake formed behind the dam reached more than 165 miles upstream.

The impressive project went far toward taming the irascible Missouri. For example, in the historic flood of 1952, Fort Peck was credited with shaving an entire foot off the crest at Omaha. But alone, it was not enough.

Meanwhile, in the Flood Control Act of 1944, Congress authorized the celebrated Pick-Sloan program, a marriage of proposals put forth by the Army Corps of Engineers and the

The Missouri River's breathtaking beauty above Fort Peck Dam belies the nickname, "Big Muddy."

Bathed in the sun's glow, the capricious Missouri River flaunts unexpected riches.

Bureau of Reclamation. The program was championed by two innovators in the water resources field — Lewis A. Pick, Missouri River Division Engineer who would ultimately serve as Chief of Engineers, and W. Glen Sloan, regional engineer for the Bureau.

Trigger for the basin-wide plan was the massive floods of the early 1940s, some of which approached the magnitude of the 1881 super flood. Not only were these disasters major blows for river communities, but they raised the possibility that the war effort would be affected.

Fort Peck was incorporated into Pick-Sloan, and the next two main stem projects begun under the joint plan were dams at Fort Randall, S.D., and Garrison, N.D., in 1946. Power generation units at both dams were in operation by 1956. The massive 230-mile reservoir behind Oahe Dam at Pierre, S.D., began forming in 1958 after a decade of construction.

Lowermost of the six, Gavins Point near Yankton, S.D., was begun in 1952 and created 25-mile long Lewis and Clark Lake, a vacationer's dream in the dry lands of the Midwest. The last major dam was begun in 1959 at Big Bend near Fort Thompson, S.D. Power at Big Bend "went on the line" in 1964.

What of the ledger sheet?

Taxpayers spent $1.146 billion for the six impressive projects but, from an economic standpoint, they remain one of the nation's best investments.

Through Fiscal Year 1979, the projects are credited with preventing flood damages in excess of $1.533 billion — more than their total cost. Revenues from power generation have totaled $990 million. Annual maintenance cost for the dams, based on the average for the past three years, is $19.6 million.

MODERN NAVIGATION

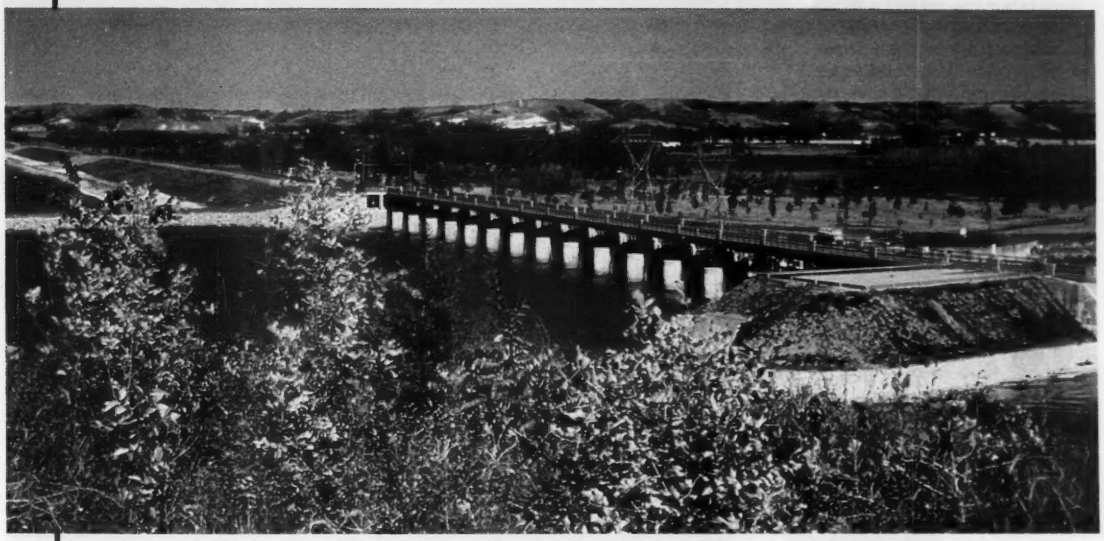
River navigation, of course, "bottomed out" in the late nineteenth century, but the advantage of continuing the work for flood reduction kept the project alive and popular with residents along the river's banks. Recurring floods, coupled with the enervating drought of the 30s, increased popular interest in maintaining a stable river through the wet and dry cycles. This led to construction of the main stem and tributary reservoirs which were part of Pick-Sloan.

The resurgence of navigation began in the latter half of this century. In 1947, total commodity movement on the Missouri, Sioux City, IA., to the mouth, was 304 thousand tons. However, by 1979 shipments exceeded 3.3 million tons — a thousand percent increase. Corps of Engineers involvement with the Missouri River basin during the period has been beneficial by many measuring sticks, but it also has earned its share of criticism and comment from the public.

The rebirth of commercial navigation on the Missouri is the result of several factors, economic and political. Early authorizations called for a six-foot deep navigable waterway; whereas, the 1945 Congressional authorization increased the dimensions to 300 feet wide by nine feet deep and provided for a series of structural works for stabilization of the river banks.

Since no locks and dams are located in the navigable reach of the Missouri, it is considered an open river waterway. It depends on regulation of flow from the upstream dams and reservoirs. To maintain full service to navigation, target flows are maintained at 31,000 cubic feet per second (cfs) at Sioux City and 41,000 cfs at Kansas City.

Objective of the Corps of Engineers program in constructing the authorized project has been to control the river by "training



Gavins Point Dam, the smallest in the main stem system of dams on the Missouri River, produces $4,055,000 in average annual benefits.

structures — dikes and revetted banks;" thus, minimizing the need for dredging.

The structures have changed the characteristics of the old meandering river in two respects: first, the river has been straightened by cutting off or reducing the worst bends and loops; and second, the river has been narrowed, forcing it to run deeper and faster.

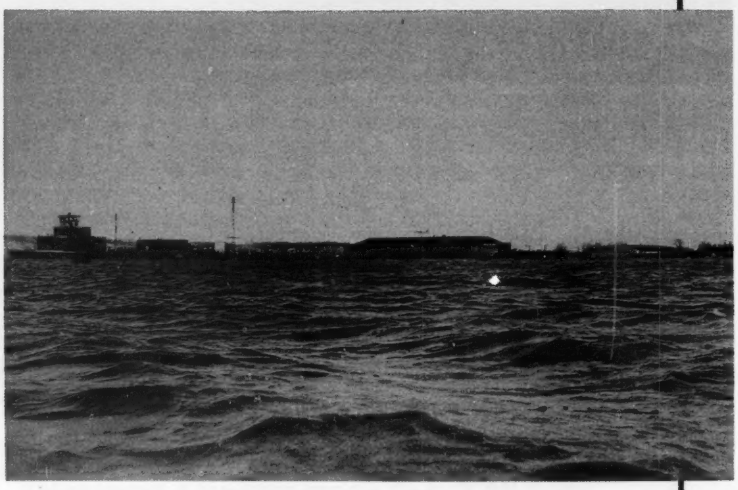
The stabilization and improvement of the channel, as originally conceived, is nearly complete. The project still must be fine-tuned to bring it to its maximum capacity while still balancing all features without endangering the environment.

Although some would have the river free again, older residents of the valley remember all too well that the Missouri as a free river can and has threatened their homes, their jobs and their very lives.

ENTER THE MRMB

So, the love-hate story continues. A price was paid for taming this wild and raucous river. Among the debits have been the effects on fish and wildlife. In many cases, the creatures that lived along the river had to find new homes because the once abundant wetlands and lush cover had given way to the farmer's plow and the urban dweller's macadam. In fact, the project has added

Reaching a crest of 30 feet, the 1952 Omaha flood surpassed the previous highs of 1881 and 1943. Looking southwest from 14th Street dike these telephone poles show the flood's severity.



The flood of 1943 dumped seven feet of water on the Omaha Airport.

approximately 188 thousand acres of prime cropland along the river — in many cases at the expense of habitat. Good news for the economy, rough on ecology.

The deeper, narrower, swifter channel also contributed to a change in the types of fish inhabiting the river.

So, as river construction nears completion, the Army Corps of Engineers has shifted emphasis to these current priorities. The Missouri River Management Board, headed by Col. C.A. Selleck, Jr., Missouri River Division Engineer, is girding to meet the challenge. Included on the Board are the top managers and technical experts from the Missouri River Division.

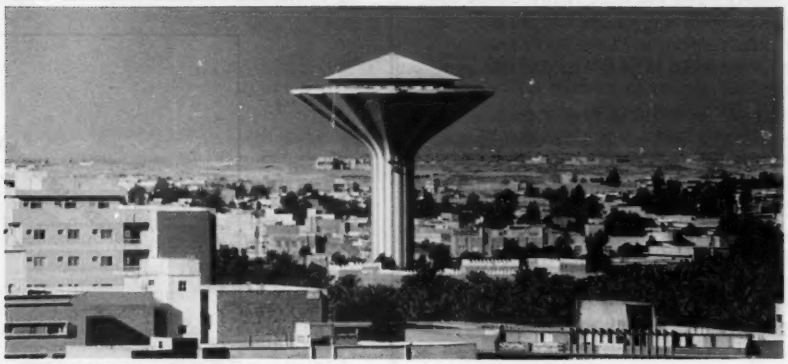
They will soon recommend a plan to mitigate losses of fish and wildlife. Nearing completion are studies of economic benefits of the project, an analysis of channel degradation, a revised master plan for recreation development and studies of the flood plain as part of the Missouri River Basin Commission's program to manage better this vital region.

Thus, the Missouri River —

A success story? A resounding "Yes!"

A challenge? Beyond question, one of the greatest! ■

Urban Water Supply Planning



by Duane D. Baumann and John J. Boland

Throughout history, concentrations of population have always been associated with large-scale water supply facilities. In the Middle East, in Central America, in the American Southwest — long-extinct civilizations have left evidence of their dependence upon water supply. The Sanitary Revolution of the late 19th and early 20th centuries, by insuring the safety and palatability of urban water supplies, only increased the dependence of urban civilization on water. The dependence is no less evident today. However, as the water and other resources of the United States are more widely and intensively known, the efficiency with which they are used becomes of greater concern.

Unlike the past, present urban water supply planning is a drastically different, challenging, and complex task. Traditionally, the planning process started by projecting the population to be served, estimating per-capita water use, and then simply multiplying one projection by the other to derive the future water use. Armed with an estimate of future water need, the problem was to identify adequate and available sources of supply, usually additional reservoirs and/or well fields. However, the problem today is not solely an inadequacy of supply; instead a wide range of factors have an influential and important role in the planning and management of our urban water resources. Consequently, new techniques of planning and methods of evaluation will need to be developed. In addition, water management policies and practices will be modified. As early as 1973, the U.S. National Water Commission noted that:

> **"To increase efficiency in water use and to protect and improve its quality, and to do these things at least cost and with equity to all parts of the country . . . require major changes in present water policies and programs."**

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Since 1973, there have been substantial changes in the process of planning and management of our urban water resources. For example, the U.S. Federal Water Resources Council has developed and recently revised the *Principles and Standards for Planning Water and Related Land Resources* and the U.S. Army Corps of Engineers has implemented new guidelines, such as the *Planning Process: Multiobjective Planning Framework,* and developed environmental impact analyses for proposed projects.

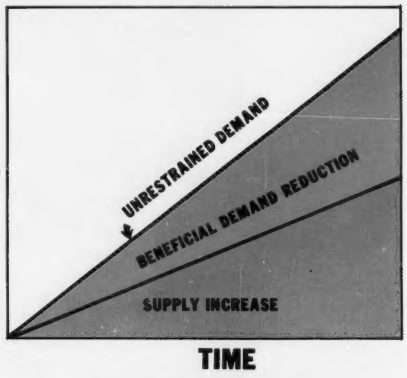
Concurrent with changes in the planning process has been a shift in perspective, that is, to a broader range of alternatives. The traditional response to increasing demand for water has been the development of additional supply. Those alternatives, for example, that would modify demand have been generally ignored. Similarly, this reliance upon technologies to increase supply, instead of policies to modify the schedule of demand, has been evident in another water resource problem — flood control.

In planning for urban water the challenge is to determine the optimum combination of all alternatives to balance the supply and demand. Not only are the alternatives that increase supply considered, but those options that modify the demand for water are also evaluated, such as water conservation.

Water Conservation: Renewed Prominence in the 1980s

The first indication of widespread interest in urban water conservation appeared shortly after 1970. The National Water Commission conducted a study of the potential for water use reduction through conservation practices, including pricing policy, and discussed water conservation as an alternative to, or adjunct of, water supply augmentation. Some urban water suppliers began to encourage conservation practices by their customers (for example, Washington Suburban Sanitary Commission, *A Customer Handbook on Water-Saving and Wastewater Reduction, 1972*). Further attention to water conservation grew out of the realization that reduced water use may result in reduced sewer flows. The Clean Water Act of 1977 specifically requires measures to reduce wastewater flows as a condition of eligibility for wastewater treatment facility construction grants.

It may appear puzzling to some why conservation has gained national prominence in light of the current and future patterns of water use. For example, according to the U.S. Water Resources Council, Second



National Assessment, the amount of withdrawal[1] in the U.S. is expected to decline from 1975 levels by nine percent by the year 2000. This phenomenon is caused primarily by industrial water use which is expected to decrease 62 percent over this time period.

Recycling, which already has a significant effect in the reduction of industrial water use, and water use efficiencies are expected to exert an increasingly important role in projected water use. Hence, the national emphasis on water conservation is already reflected in the projections of water use.

However, the rationale for considering water conservation in water supply planning is not solely a function of the relationship between supply and projections of use; other factors today impinge upon the efficiency of water use and planning to meet future demand. Data on national aggregate water use have little relevance because urban water supply planning is a local phenomenon. It is at the local level where the

[1] *Withdrawal of water is that amount taken from a surface or groundwater source. Consumptive use is that portion of withdrawn water not returned to the source.*

range of factors that determine the efficiency of water supply production is of most interest.

There are primarily six forces that influence urban water supply planning today. First, there are environmental constraints in the procurement of additional supply: new reservoir sites have become increasingly scarce, and groundwater resources are becoming inadequate to meet the demands of urban areas. Gilbert White has noted the depletion of groundwater as one of the six most important water resource problems in the world, and particularly in the United States. A second set of problems that constrain urban water resource planning is the existence of new laws and regulations: political, legal, and institutional problems of interbasin transfers have proliferated until it is nearly impossible to plan for a transfer of water from one basin to another. Third, the concern for water quality, which mushroomed during the 1970s, has significantly constrained the opportunities in urban water management. Water quality standards have been established by passage of the Federal Water Pollution Control Act Amendments (1972), the Safe Drinking Water Act of 1974, and the Clean Water Act of 1977. Fourth, the costs of energy have increased at record rates and resulted in substantial increases in water rates. Fifth, an additional factor in the increased costs of water resource development since the early 1970s is the cost of money, which this year has witnessed a record high prime interest rate of 20 percent. Finally, in some urban areas, especially those experiencing a growth in population, the demand for water continues to rise.

Water Policy Reform: Federal Response

Water conservation became an integral part of national water policy in 1978, when President Carter, in his Water Resources Policy Reform Message of June 6, 1978, stated:

> **"Managing our vital water resources depends upon a balance of supply, demand, and wise use. Using water more efficiently is often cheaper and less damaging to the environment than developing additional supplies. While increases in supply will still be necessary, these reforms place emphasis on water conservation and make clear that this is now a nationall priority."**

Moreover, President Carter's Water Policy Message not only called for a new national emphasis on water conservation, but required all Federal agencies to in-

— Often, environmental constraints limit additional supply development.

corporate water conservation requirements in all applicable programs, and set forth a program which would provide states with financial assistance in planning for water conservation. Water conservation has been declared one of the priority areas to receive support from the U.S. Office of Water Research and Technology.

A recent GAO report underlines President Carter's Water Policy Message recommendations that call for increasing technical assistance for water conservation by farmers and urban dwellers and solving constraints that prevent or impede the implementation of better water management and conservation practices. In a related report, the GAO concluded that a major constraint to the implementation of the available conservation measures was the lack of knowledge about their effectiveness.

The expectation of these national efforts is that water conservation programs will contribute significantly to solving our national urban water resource management and planning problems by:

- making available additional water supply for other uses;
- obviating or delaying the construction of expensive additions to supply;
- reducing the size or delaying the construction of wastewater treatment facilities; and,
- reducing the financial costs and energy requirements for the procurement, production, and distribution of water supply and the treatment of wastewater, especially important since the passage of the Clean Water Act of 1977.

In response to the President's Message, the Corps of Engineers intensified its efforts to incorporate water conservation into the Civil Works program. In 1978, research was undertaken to develop appropriate methodology. The first effort was a survey and appraisal of the available information about water conservation. In order to provide initial and readily available information to Corps' planners, a selection was made of the literature reviewed and was subsequently published as an annotated bibliography.[2] From the experience and data base, critical questions were raised, and deficiencies and essential needs were identified. Specifically, these were:

- What is conservation?
- What is the effectiveness of available conservation measures?
- What are the principles for evaluation of water conservation measures for municipal and industrial water supply?

The Role of Conservation in Water Supply Planning[3] addressed these questions. A precise and practical definition was formulated, estimates of the effectiveness of conservation measures were identified and appraised, and a methodology was developed not only to evaluate specific conservation measures but to integrate measures into water supply plans.

The next task was to develop a manual for the evaluation of water conservation for municipal and industrial water supply. *The Evaluation of Water Conservation for Municipal and Industrial Water Supply: Procedures Manual*[4] includes a description of the concepts, procedures, and techniques of measurement for developing and evaluating water conservation proposals for municipal and industrial uses of water.

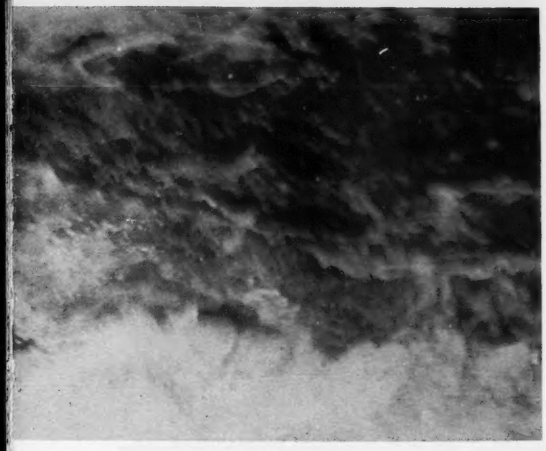
The objective of the Procedures Manual is to integrate water conservation planning with water supply planning in a logical, consistent manner. The gap between future demand and supply may be reduced by water supply augmentation, by water conservation, or, and more likely, by a combination of the two approaches.

What is Conservation?

Before any attempt can be made to determine whether conservation should or should not be implemented, a clear, precise, and practical definition

[2] *An Annotated Bibliography of Water Conservation, IWR, Water Resources Support Center, Ft. Belvoir, VA 22060*

[3&4] *Are available from the the same address cited in footnote 2.*



— Properly applied conservation measures may enhance environmental quality, through instream flows for fishing, boating and swimming.

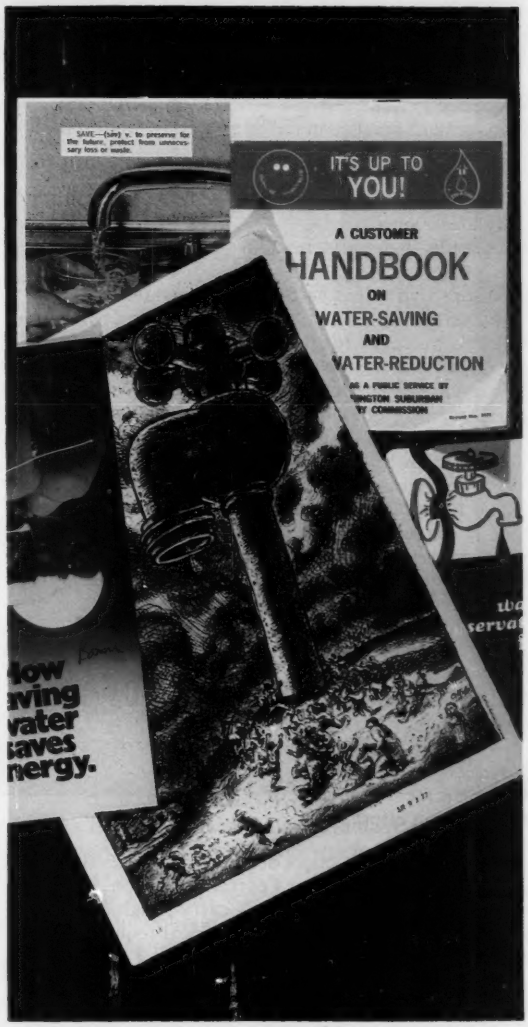
of conservation is required. Most past definitions of conservation have not been precise and consequently were not easily translated into policy. For example, to some the concept of conservation may mean a reduction in use, to others a development of new supplies, and to others the restriction of specific uses of water.

The most common definition of conservation was provided by Gifford Pinchot, considered by many as the Father of Conservation, who stated that "conservation is the use of natural resources for the greatest good of the greatest number for the longest time." Yet, to the planner who must formulate and evaluate water conservation measures, how does such a definition help? What is the greatest good? How should it be determined? Who determines what the greatest good is? Is the greatest good achieved by always striving to reduce water use? Who are the greatest number? How far into the future can we hope to plan?

In response to the President's Policy Reform Message several definitions of conservation were established by numerous groups. In a report by the U.S. Department of Interior, the objective of conservation was defined as "the wise and judicious use of available supplies." But, what does wise and judicious mean? Similarly, the ad hoc Committee on Water Resources, Commission on Natural Resources of the National Academy of Sciences, failed to distinguish between those actions or policies that qualify as conservation and those that are simply efficient water management strategies.

Comprehensive water supply planning requires the evaluation of three basic sets of considerations, including the merits of demand reduction practices; the potential for more efficient utilization of existing supplies; and the need for new supplies. The first two categories, which are demand management strategies, are included within the definition of water conservation.

But, should all measures that reduce water use or loss be implemented? And if so, to what extent; that is, how much curtailment of water use? The answer is quite clear and precise: Only those measures that re-



duce the use, or loss, of water without disproportionately increasing the use of other resources can qualify as conservation. For each measure the total beneficial effects of the reduction in water use and/or water losses must be greater than total adverse effects.

Water conservation, then, is defined as "any beneficial reduction in water use or water loss." A water management practice qualifies as a conservation measure when it passes two tests:

- It conserves a given supply of water by reduction in water use or water loss.
- It results in a net increase in social welfare.

More specifically, the first criterion states that implementation of a water management practice must result in water use (or loss) which is less than it would have been had the measure not been implemented. The end result is in the reduction of water use or loss so that a segment of existing or future water supply is available for uses that otherwise would not have been served except by the provision of new supplies.

The second criterion is that the reduction in water use or loss must be beneficial. That is, in order to qualify as a conservation measure, implementation must result in a net positive contribution to the Natural Economic Development objective, the Environmental Quality objective, or both.

Types of Conservation Measures

Water conservation measures have been classified as (Table 1):

- Regulatory practices;
- Management practices; or
- Education efforts.

The regulatory practices are those measures that are dictated by local, state, or Federal legislation. In general, these measures would likely carry penalties or sanctions for noncompliance, e.g., local requirements of low-flush toilets in new dwelling units.

Management practices are those implemented by the local water utility or by the responsible units of government that result in a beneficial reduction in water use or water losses. These include measures such as leak detection, metering, or modification of pricing policies.

Educational campaigns are directed toward voluntary beneficial reductions in water use or losses. For example, information on conservation efficiency in lawn sprinkling may result in a reduction of lawn water use without damage to lawns.

How Effective are Conservation Measures?

It is not uncommon to read about enormous reductions in water use for a specific community attributed to conservation. For example, Schoenfeld's study in Rhode Island noted that municipal water use can be reduced during periods of shortage by 35 percent without drastically changing life styles.

How useful are such estimates in assessing the role of conservation in urban water resource planning? The authors believe such estimates are of little value and frequently misleading.

Based upon a review of the literature, the major conclusion about the effectiveness of water conservation measures is that comparatively little is known. Concerning information about the probable adoption of voluntary conservation measures, there is even less.

There are two major reasons for the variation in estimates of the effects of specific water saving strategies. First, many estimates are applicable only for the conditions at the sites from which they were derived. Second, the studies to estimate effectiveness may be poorly designed, leading to erroneous conclusions.

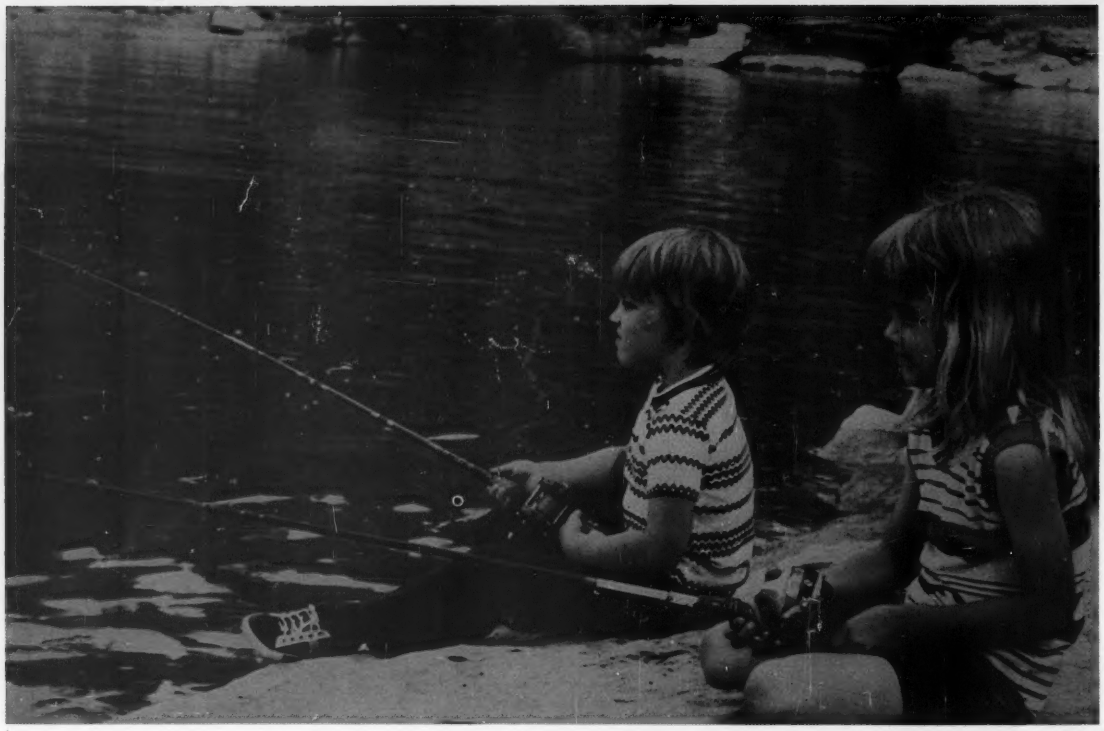
Clearly, during a prolonged drought residents are more likely to employ water reducing devices than during average or wet years; hence, estimates on effectiveness measures during drought cannot be assumed to be applicable during nondrought years. However, most of the estimates of effectiveness have been derived during periods of drought. This is particularly true today concerning the recent California drought. In addition to drought, average weather (climate) varies from place to place and is an important determinant in water use and therefore on the effectiveness of water conservation measures. Similarly, the

TABLE 1

ILLUSTRATIVE LIST OF WATER CONSERVATION MEASURES

REGULATIONS	MANAGEMENT	EDUCATION
Federal and State Laws and Policies A. Presidential Policy B. PL 92-500 C. Clean Water Act Amendment 1977 D. Safe Drinking Water Act Local Codes and Ordinances A. Plumbing Codes for New Structures B. Retrofitting C. Sprinkling Ordinances D. Changes in Landscape Design E. Water Recycling Restrictions A. Rationing 1. Fixed Allocation 2. Variable Percentage Plan 3. Per Capita Use 4. Prior Use Basis B. Determination of Water Use Priorities 1. Restrictions on Public and Private Recreational Uses 2. Restrictions on Commercial and Institutional Uses 3. Car Wash Restrictions	A. Leak Detection B. Rate Making Policies 1. Metering 2. Pricing Policies a. Marginal Cost Pricing b. Increasing Block Rate c. Peakload Pricing d. Seasonal Pricing e. Summer Surcharge f. Excess Use Charge C. Tax Incentives and Subsidies	A. Direct Mail B. News Media C. Personal Contact - Speaker Program D. Special Events - School Programs

socio-economic conditions within each community which influence the effectiveness of water conservation vary markedly. Is the community primarily residential or is there significant industrial and commercial water use? What is the price of water? What is the income of the customers? What is the lawn size of the residential customers? In order to calculate more precise estimates of water use reduction, community water use must be disaggregated and relevant information on the characteristics of each user class must be obtained to derive more precise estimates of effectiveness. Finally, there is little or no information about the factors affecting the adoption of voluntary water conservation measures. The results of educational campaigns are usually based upon communities under crisis conditions, such as drought. Clearly, additional research is required to determine the factors that affect consumer adoption of water conservation measures during noncrisis situa-



— Conserving water makes the scarce resource available for a multitude of uses.

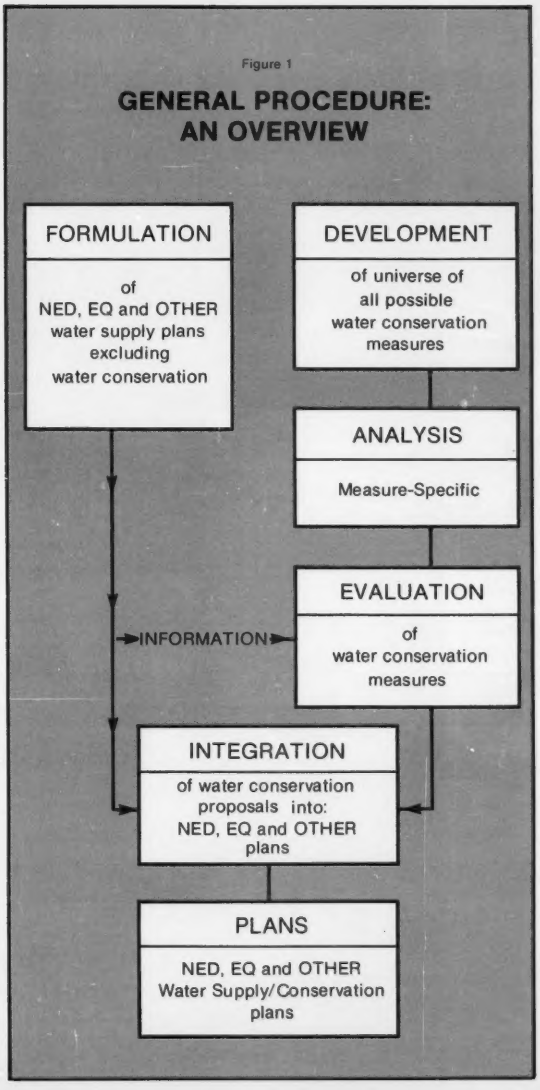
tions such as the current studies funded by the U.S. Office of Water Resources and Technology. Such information will be useful in estimating the effects of proposed measures and in the formulation of a cost-effective educational campaign.

Conservation in Water Supply Planning

The extent to which water conservation measures should be included in a particular water supply plan is determined by testing each possible measure against that plan, and identifying and measuring advantageous and disadvantageous effects. The Procedures Manual describes this process, which consists of three phases:

- Measure-specific analysis, which is independent of the characteristics of the water supply plan(s);
- Evaluation of conservation measures, which incorporates the characteristics of the water supply plan(s); and
- Integration of the water conservation measures into the water supply plan(s), forming the final water supply/conservation plan(s).

The procedure is shown in Figure 1. Prior to initiating the first phase, a list of all possible water conservation measures is developed, including those based on regulation, management actions, and educational efforts.



SUMMARY

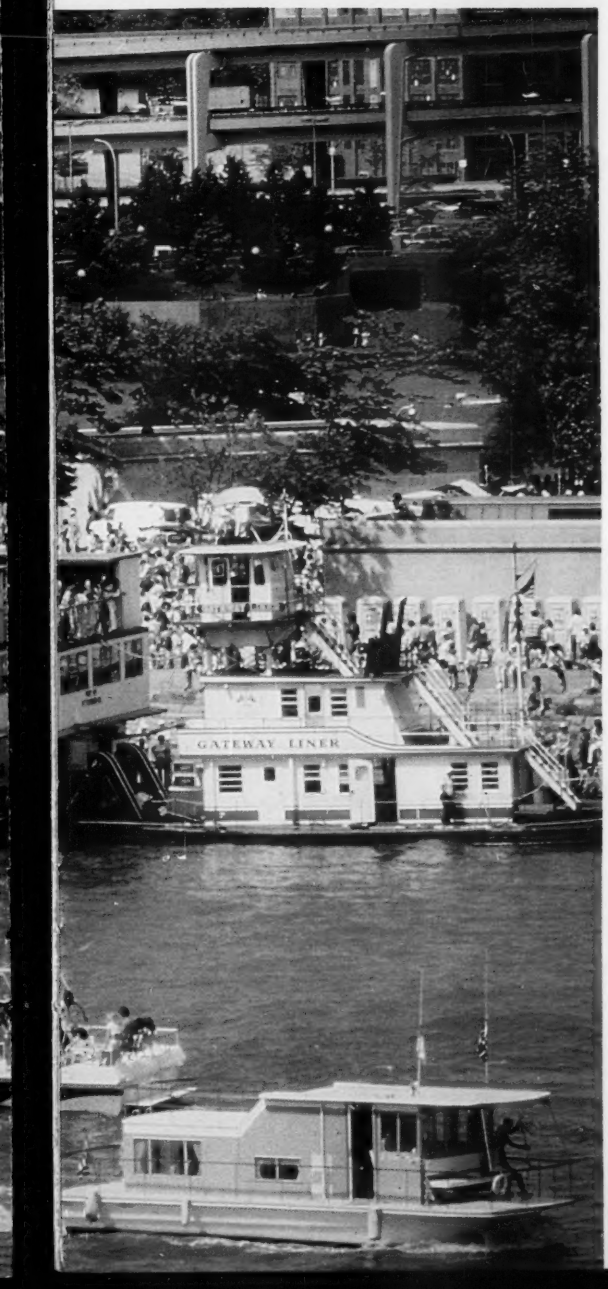
Water conservation is the **beneficial** reduction in water use or in water losses. It is important to reemphasize that water conservation according to this definition is neither a new nor a different water management technique. Instead, water conservation practices are merely a **subset** of all alternatives that comprise efficient management of water resources.

The challenge for the planner is to consider the efficient allocation of the water resource at every stage of distribution and use. Among the desirable practices are some which involve beneficial reductions in the use of water or in water losses; it is these practices that in our judgment are water conservation. The cautions of measuring the effectiveness of potential water conservation measures have been discussed; and, the methodology to assist the planner in evaluating water conservation measures for possible integration into water supply plans has been developed and been briefly described. ■

America's Wa
Are Loc

aterfronts oking Better!

by Don Henry



Water! Whether in lakes, rivers, canals or oceans, the attraction it held for Americans as they built their cities and towns has been magnetic. The benefits, both aesthetic and economic, of settling near a waterfront have been influential since the earliest pre-colonial times. We have used water for transportation, sustenance, energy, commerce, recreation and spiritual renewal. Indeed, water offers a primal attraction—it soothes, mesmerizes, excites and provides an elemental form of open space and high contrast relief from city congestion.

Poet e.e. cummings put it most succinctly: "Everything looks better near water."

As applied to America's waterfront cities at the start of the 1980s, this observation can now be more accurately stated "Everything is looking better near water." For the sad fact is that until recently the waters and the areas alongside them which were originally the life blood and raison d'etre for our coastal, river and lakefront communities have been exploited, fouled and ignored as if they are not the priceless assets they once were.

This picture, fortunately, is changing in cities across the land. Just as our nation has "rediscovered" countless other aspects of its heritage in recent years, we are learning, as environmental planner Roy Mann observed in his book, *Rivers in the City*, that urban riversides, lakefronts and coastal areas "hold the greatest hope for beginning a revival of confidence in the urban physical environment."

This evolution of philosophy—that a commitment to our waterfronts is a commitment to our cities—is coming about because of a number of factors happening independently and in combination to produce a renewed interest in their revitalization. Most notable has been the dwindling source of usable land located near population centers for recreation, housing, commerce and open space. As demands of all of these uses soar, along with the costs of fuel and transportation to reach outlying areas, the inevitable result has been the recycling of blighted or underutilized waterfronts close to home. Secondarily, we have come to appreciate our historic coastal structures and ways of life, as well as the variety, the charm and the beauty a waterfront area can so easily add to our cityscapes.

These practical and aesthetic considerations have produced a variety of creative techniques at all levels of the public and private sectors which make revitalization efforts possible. Funding, of course, is the essential ingredient to any political process that produces changes in our cities and in the lives of their citizens. A look at a cross section of contemporary urban waterfront projects reveals a mix of funding strategies, waterfront uses, and citizen efforts that have worked and are working in America's waterfront communities today.

San Francisco's extensive shoreline has always been the major focal point of the city. The western edge, from the ocean to Fort Mason, is a natural beach and bay shoreline, accessible to the public as a part of the Golden Gate National Recreation Area. Fisherman's Wharf is heavily tourist oriented, with a concentration of commercial/recreational uses. The central and southern waterfronts are industrial areas and the location of major new shipping activities. However, the northeastern waterfront, adjacent to the financial district and the

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Pittsburgh's two-day River Regatta, with boat races and waterskiing demonstrations, drew 250,000 spectators each day.

most urbanized portion of the city, has declined from the former thriving, active port it was from the Gold Rush days through World War II.

This decline in use and vitality came about as the northeastern waterfront became increasingly severed from the rest of the city, first by the competition of the Bay Bridge and the diminution of the role of ferries and the Ferry Building as a transportation terminal. Later, the Embarcadero Freeway created a visual and physical barrier to San Francisco Bay while providing only indirect access to the waterfront. Finally, changes in water transportation technology, chiefly containerization, required backland support areas and costly new facilities which San Francisco could not accommodate as well as the Port of Oakland across the Bay.

As a result, even though portions of the northeastern waterfront continue to be used for traditional break-bulk cargo handling and shipping related activities, much of the area is characterized by vacant and dilapidated piers and underutilized land. This picture, however, is changing as a result of an Action Plan developed over a number of years by the city's Redevelopment Agency, Planning Department, Port, a team of consultants, and an advisory committee.

The plan placed its highest priority on maintaining existing break-bulk cargo handling and ship repair uses in this sector with new maritime and industrial activities to be located in other parts of the waterfront which are more capable of accommodating deep draft ships, trains and storage space. The plan also emphasizes the development of open space and public recreation along the water's edge, including parks, piazas, promenades, bikeways, fishing piers, open water areas and a small boat harbor. Such uses are intended to create a mixture of day/night activities and foster continuous pedestrian movement along the waterfront. A major new mixed income residential development consisting of over 2500 dwelling units is proposed south of the Bay Bridge, to be characterized by high density, low to mid-rise structures, recreating the traditional flavor of San Francisco's neighborhoods.

"...Water offers a primal attraction—

it soothes, mesmerizes, excites and provides an elemental form of open spaces and high contrast relief from city congestion."

Seattle's Waterfront Park.

Finally, proposals which would have further cut off the waterfront from the city and add more fill into the bay have been laid to rest. The plan proposes to reintegrate the waterfront with the city. Barriers to the waterfront, including the Embarcadero Freeway, and parking under it and on open piers, would be removed. The Embarcadero roadway would become a landscaped waterfront boulevard, linking the northeastern waterfront with other portions of the shoreline. A historic rail transit system would run along the Embarcadero, reducing the need for auto travel and on-site parking. A promenade would allow for movement along the water's edge, and pedestrian and bicycle paths would connect recreational areas with community facilities, historic and architectually significant buildings, residential areas and employment centers.

State programs for which the city may qualify include funding for marina development, open space/recreation, historic preservation and housing. These programs include the Harbors and Watercraft Revolving Fund administered by the Department of Navigation and Ocean Development; the California Housing Finance Authority; and, the Land and Water Conservation Fund and the Historic Preservation Grant Program, both administered by the U.S. Department of the Interior's Heritage Conservation and Recreation Service through the California Department of Parks and Recreation and the State Historic Preservation Office, respectively.

Federal funds are also available for the program from the Department of Housing and Urban Development (HUD) Community Development Block Grants and Urban Development Action Grants, HUD rental assistance for low and moderate income households, and Economic Development Administration (EDA) grants for public works and economic adjustment. The city is currently using the EDA program to remove dilapidated piers and to construct the waterfront promenade.

This combination of potential funding sources will be utilized in combination with commercial development in leased buildings to bring about a mix of public and private areas without imposing a drain on the city's economy. Most important, it will allow for the preservation of San Francisco's maritime character and its strong sense of heritage while increasing the physical and visual access to the Bay which gives San Francisco its identity.

Austin, Texas' Fiesta Gardens is the scene of annual ethnic and folk festivals on Town Lake.

The esplanade along the Savannah River. Warehouses at left, once vacant, have been refitted as shops and restaurants.

Portland, Oregon has likewise returned to its origins along its water, the Willamette River. Twenty years ago, Portland's downtown waterfront was typical of the American urban waterfront city with its deteriorated and vacant turn-of-the-century commercial architecture and its riverbanks turned over to an expressway along a polluted and lifeless river. The success the state was having in cleaning up the Willamette and the adoption of the Willamette Greenway Program in 1967 led Portland in the early 1970s to take a fresh look at its waterfront. A four-lane freeway has been eliminated and replaced by a mile-long waterfront park. Once again, the riverfront is frequented by the people of the city and visited by a growing number of foreign vessels and cruise ships. The waterfront district itself is bustling with new construction and historic restoration.

After several public hearings on the issue, the state made the decision to remove the old Harbor Drive Freeway and to offer to sell the land to Portland. Major office development projects already underway adjacent to the park provided the base for a $10 million downtown waterfront bond in 1975. A grant from the Land and Water Conservation Fund (U. S. Department of the Interior) for $1.2 million made possible the acquisition of a portion of the 73-acre park and promenade. The city is currently focusing its attention on developing Waterfront Park's attractions — a marina, walkways, bicycle paths and vista points. In addition to providing open space

and river access, these waterfront improvements have stimulated major historic preservation and economic development thrusts.

Downstream from Waterfront Park is the St. Johns Neighborhood, a former village annexed to Portland in 1915. This section of Portland is also an area of waterfront redevelopment, including a residential housing project that encompasses about 90 acres, with almost a mile of greenway on the riverfront and pedestrian access from surrounding residential areas. This project is being funded in part by a $9 million Urban Development Action Grant. Through another grant from the National Endowment for the Arts, the city has hired an architectural firm to assist in developing a design scheme, and a series of workshops were conducted covering various aspects of the commercial building rehabilitation process. This is Portland's first attempt to promote direct assistance to a neighborhood commercial area and it is expected to serve as a model for other parts of the city.

Eureka, California is also working on ways to keep a mix of activities on its waterfront in order to maintain both the residential/hotel aspects of its historic port as well as the traditional shipping and maritime interests. Eureka was a major port in northern California for the lumber and fishing industries, but in recent years the waterfront area has declined, although many of the original buildings remain.

To bring new life into the area, the City's Redevelopment Agency is planning, in cooperation with the California Coastal Conservancy, a park, and a new boardwalk at the site of a former lumber storage area. Other economic development will be brought about with local tax increment funds and Community Development Block Grants for rehabilitation of the housing and hotels along the waterfront, and the use of HUD's subsidized rent program ("Section 8") will enable the present tenants to remain in the buildings. The Economic Development Agency's grant program for economically distressed communities, along with state loans, will be utilized for construction of a marina complex and a fish processing plant. This plant will be a key to keeping the harbor a working place for the uses it has had in the past. All of these activities will be coordinated in a master plan to improve pedestrian access to the water by closing streets and alleys, developing bicycle paths and creating inviting open space areas.

Historic preservation on a grand scale has also been a major part of Boston's waterfront revitalization. The Boston Naval Shipyard, a national historic landmark listed in the National Register of Historic Places, is located in the Charlestown Section along the Inner Harbor Waterfront. It is one of the nation's oldest shipyards, established by Congress in 1797.

In 1973, what seemed to be an economic catastrophe for Boston occurred when the U. S. Navy announced plans to close the 130-acre shipyard which employed thousands of skilled workers and provided many contracts to private enterprise. After two years of marketing attempts, Boston officials concluded that the shipyard was obsolete for modern industrial use, and instead developed a plan to convert the site to a mix of residential and commercial uses which is resulting in new jobs, $3 million in tax revenue, 1200 additional housing units, and an attractive new waterfront for the Charlestown area. The solution for reuse also represents a creative utilization of the laws which govern the disposal of surplus Federal property and of tax incentives designated to stimulate the rehabilitation of historic structures.

Recognizing the potential in acquiring the shipyard, and with a reuse goal predicated upon creation of an economically viable project, the Boston Redevelopment Authority began working with GSA to refine plans for acquisition of the surplus portions of the

The Parade of Tall Ships in 1976, marking America's Bicentennial, visited Baltimore's refurbished harbor.

The Maumee River waterfront in Toledo, Ohio.

"We have come to appreciate our historic coastal structures and ways of life, as well as the variety, the charm and the beauty a waterfront area can so easily add to our cityscapes."

shipyard. The development strategy was to take maximum advantage of the attractive physical location of the shipyard on Boston's waterfront. The presence of the U. S. S. *Constitution* National Historic Site and its potential for attracting over 1,000,000 visitors a year would be a major impetus for tourist-related investment in the shipyard.

Extensive economic, environmental, architectural, and transportation analyses concluded that the shipyard was too large, varied, and complex for a single reuse, and that a mixed development concept was more appropriate. The concept utilizes a mixture of compatible uses that take advantage of the special characteristics of the site and that coincide with growth sector needs of the Boston economy.

In all, 105 acres of land and water were made available to the Boston Redevelopment Authority under the surplus property program. Sixteen acres were transferred at no cost for park and recreation purposes with the condition that they will always remain a park. The National Monument Area, encompassing 31 acres and 30 buildings, was also conveyed at no cost, but the city has taken advantage of a 1972 amendment to the Federal Property and Administrative Services Act which allows revenue-producing uses on historic surplus property disposals provided that the income received in excess of expenses is used for preservation/restoration of the property and for recreation. Thus, the majority of structures on this parcel will be leased to private developers and restored according to the Secretary of the Interior's Standards for Rehabilitation. The allowable adaptive reuses include primarily commercial and retail enterprises, some residential space, offices and light manufacturing.

The final 58 acres of land and water was purchased at fair market value from GSA, with the right to subdivide the parcel for purchase and development by private enterprise. This development is guided by recommendations of the Advisory Council on Historic Preservation and the Redevelopment Agency, for economic feasiblity.

What initially appeared to be an economic disaster has emerged as a vital new area of growth for Boston. Equally as important as the economic factors, however, is the creative approach to recycling the vast area of land, water, and buildings encompassed by the shipyard. The plans for redevelopment include a unique combination of historic preservation, new development, and public recreation amenities that will contribute significantly to the quality of life in Boston.

Palisades Bluff on the Meramec River, is within easy reach of St. Louis' boating enthusiasts.

Seattle, Washington is dealing with the question of revitalization of its port in a different context. The City's Community Development Department and its Port Commission are striving to keep the port area a modern, viable commercial enterprise while adding parks, public access and recreation amenities for the general public. The port is subject to the Statewide Shorelines Management Act, enacted in 1974, which assigns underlying approval authority to the Community Development Department for new development within 200 feet of the shoreline.

As the port modernizes, replaces terminals, provides for containerization facilities, and expands to maintain its profitability, it is likewise attempting to upgrade its public facilities. Examples of the types of public works the port is adding include linear parks, bicycle paths, fishing piers, boat launches, marinas, and educational/historic exhibits. An overpass to connect the Seattle Center area, site of the Seattle World's Fair, with the waterfront is being jointly funded by the port and the city, while the Alaskan Seawall and Promenade is being upgraded with tax incentives for private property owners to undertake improvements. Installation of a waterfront trolly system on existing railroad tracks will facilitate waterfront transportation, with city and transit district funding.

Two piers purchased by the port from the Navy are being carefully studied for future uses, with public input on the alternatives, including possible non-port activities. In the meantime, two other piers are being renovated to provide office space and retail business facilities. One, owned by a major oil corporation, is being converted to include condominiums and a marina.

Long Beach, California is a recipient of particular assistance in its urban renovation activities, as it has been the subject of an effort of the U. S. Department of Commerce to coordinate the various applicable DOC grant programs. Long Beach is the 40th largest city in the United States but it is the sixth most financially distressed. Designated a part of the Commerce/Cities Program, it has also received assistance from the Departments of Housing and Urban Development, Transportation and Labor in developing the urban core. The overall implementation of the city's redevelopment is incomplete, but the effort being made to achieve Federal coordination of grant programs at the municipal level is having positive results: some $6.5 million in Federal activities will be phased in over a three-year period; this has in turn leveraged $700 million in private investments, as well as a sizable amount in public bond sales.

The Federal programs to date will go to the development of hotels and convention facilities, regional transportation, job training, and business development. Although these activities are not directly tied to Long Beach's waterfront, they will affect it indirectly, and more importantly the success to date will likely lead to further coordination as plans progress on the proposed marina, boardwalk, aquatic park and related facilities of the Tidelands Plan, which ties all these elements to the inland development.

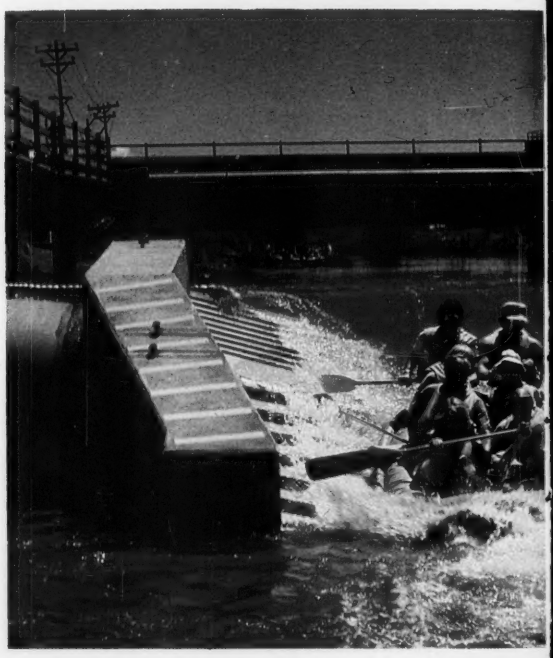
Planners indicate optimism that the various Federal and local agencies can achieve similar coordination as other programs, such as the Land and Water Conservation Fund, are added to the list. One major impetus in this effort comes from the creation last year of the Urban Waterfront Action Group, a Washington-based coalition of Federal agencies which administers waterfront related programs. At the regional level, the same agencies are meeting regularly in San Francisco to assist Long Beach and other western cities in their efforts.

One particular concern expressed by the city has been the myriad requirements and concerns involved in environmental planning and impact statements at all levels. This oft-expressed problem will be addressed by the Urban Waterfront Action Group as it assists in specific situations such as Long Beach. It will also no doubt be addressed by California State University at Long Beach in its newly proposed department of urban waterfront design, a pioneering effort at the university level in this country to address the problems and opportunities peculiar to urban waterfronts.

The Lehigh Canal is a different sort of waterfront. Its course runs through three counties in Pennsylvania and it has remained virtually intact since it ceased operations in the 1930s. In its 45-mile length, it runs adjacent to some 50 municipalities, and interest is running high among them in the idea of restoring the canal and developing a linear park.

The staff of the U. S. Department of the Interior's Historic Architecture and Engineering Record (maintained by the Heritage Conservation and Recreation Service) has recently studied the site with regard to the archeologic and historic resources along the canal, and the Lehigh, Carbon and Northhampton County governments are coordinating their planning as they acquire the property from its private owners.

"The plans for waterfront revitalization must also be self-sustaining and must have an active citizen involvement from the beginning . . ."



Littered Brooklyn streetend challenged neighborhood residents . . .

Who teamed up with organizations and city agencies to create an oasis of green and a place for neighborhood events.

Near-in kyaking and rafting is available to Denver residents.

In one of the more innovative ideas for using the water resources of a waterfront site, the counties, with assistance from the U. S. Army Corps of Engineers, are investigating the feasibility of installing low-head hydroelectric turbines along the now unused locks of the canal. This idea is made possible by virtue of nearby electric grid systems in many of the adjacent communities which would allow for relatively inexpensive tie-in to the existing electric systems. There are two alternative proposals which could result in benefits to the park and the county/city park departments. The hydro facilities could be operated by the local power and light companies, with the power generated offsetting the park's electricity costs (and additional power and light company staff expenses) or the facilities could be operated by the park itself and the electricity sold to the power and light companies. The costs for purchasing and installing the turbines would be purchased from public funds, probably through bond issues.

Although this proposal is still in the early stages of development, it clearly holds promise as a means of reducing operation and maintenance costs and utility expenses for waterfront revitalization projects on rivers and canals. The problems may be myriad, but with power costs from traditional sources soaring, hydroelectric power generated on-site at parks and on waterfront developments will doubtless be a very real concept for the future.

These examples show the variety of approaches being used in revitalizing waterfronts today. The list could go on. The Historic Preservation Grant Program alone is assisting efforts throughout the nation, including a survey of historic maritime buildings in Boston; restoration of historic ships which will in turn be the focal point of renewal efforts in Galveston, Seattle and Honolulu; a historic shipyard in Bath, Maine; a fishing wharf in Capitola, California; and a fish packing house and oyster boat on the Patuxent River in Maryland.

The utilization of one or more Federal or state grant/loan programs is clearly essential to get most projects off the ground. But it is equally clear from the examples that these programs should be seen as tools for leveraging funds from other sources. The plans for waterfront revitalization must also be self-sustaining and must have an active citizen involvement from the beginning to ensure a healthy balance of commerce, housing, recreation, cultural, historic, and maritime considerations.

Even with all of these ingredients, not all waterfront revitalization efforts are clear-cut "success stories." The problems encountered in acquiring funding are a part of larger problems common to major urban projects: planning, design, environmental concerns, staffing, minority representation, and the difficulties encountered in the consideration of recreation, open space, cultural, archeological and other non-income producing aspects of public facilities.

What, then, makes the difference between waterfront revitalization that works and those efforts which never quite get started or go aground before accomplishing their goals? The difference lies in the determination, pride and activism of citizens who identify with their waterfront past and want it to be a part of their heritage once again.

As writers Mary Procter and Bill Matuszeski observed in *Gritty Cities,* their 1978 book about 12 older American waterfront cities, ". . . They do best when they grow and change by building on those things that give them their character. Pat solutions, no matter how bold and costly, never seem to succeed as well as carefully thought out approaches that use the unique mix of existing structures and neighborhoods, traditions and industries that comprise a city's legacy."■

Events, Deeds & Deliberations

Columbia Blocked By St. Helens

In May 1980, when a tremendous explosion in the 25 to 50 megaton range blew off the top of Mount St. Helens in the southwestern corner of Washington State, the ensuing runoff of massive amounts of mud and debris resulted in immeasurable impacts to the nearby Toutle and Cowlitz rivers. As the Cowlitz ultimately debouches in the Columbia River near the Longview-Kelso port complex, dredging problems of awesome dimensions resulted for the Portland U.S. Army Engineer District. According to Corps of Engineers estimates, 40 to 55 million cubic yards of volcanic debris flowed down the Toutle and Cowlitz rivers to form a massive mound across the Columbia River. Depths were suddenly reduced from 40 feet to as low as 14 feet in portions of the reach from river mile 63.0 to 72.5, closing the Columbia to deep draft navigation.

Reacting to the unprecedented magnitude of shoaling, the Portland District immediately summoned the three Corps West Coast hopper dredges. Simultaneously, efforts were initiated to secure industry dredges to assist in emergency dredging operations so that navigation could resume at the earliest possible date. Fifty ships were caught above and below the blocked portion. With deep draft navigation interrupted, Portland area grain elevators quickly reached capacity and barges coming down the Columbia were unable to unload. Inland navigation slacked off to 20 percent of normal pending the availability of cargo transfer storage space.

Estimates indicate that the Port of Portland lost $5 to $7 million in revenues due to the reduced volume of waterborne commerce.

Round-the-clock emergency dredging operations succeeded in opening a minimal channel with dimensions of 25 x 200 feet within the original 40 x 600 foot one as of May 28. With support from the Coast Guard, limited shipping resumed during high tide periods, and by June 14 ships with drafts of 36 feet 11 inches could transit, allowing the last of the large ships trapped by the blockage to slowly churn through the narrow channel and out to sea.

In June MG E.R. Heiberg III, Director of Civil Works, Corps of Engineers, requested $215 million in emergency funds from Congress for reconstruction and restoration activities in the aftermath of Mount St. Helens. This followed a Presidential declaration of a major disaster area for Washington State, which opened up a variety of sources of funds for emergency activities. He noted that primary Corps restoration activities were for flood carrying capacity on the Cowlita and Toutle rivers and for navigation on the Columbia. Efforts on the Columbia were estimated to cost $45 million. This includes removal of about 14 million cubic yards of volcanic ash, sand and gravel from the navigation chanel and at least another 8 million cubic yards from portions of the flood plain to ensure adequate discharge capability. By comparison, average annual dredging along the entire length of the Columbia from Portland to the ocean, including the entrance channel, yields 10 to 11 million cubic yards of dredged material.

The remaining $170 million of Heiberg's request was for a variety of flood protection activities in the Cowlitz and Toutle. A number of protective works are being evaluated and implemented, including dredging, settling basins, levee raising or relocation, debris retaining structures, and combinations of these measures.

At least $122 million is earmarked for the removal of 25 million cubic yards of debris from the Cowlitz River. This is the equivalent of one million cubic yards every river mile. The runoff from the volcano into the Toutle and Cowlitz drainage basins northeast of the mountain reduced these rivers' discharge capacity by an estimated 85 percent, giving rise to fears of autumn flooding. A minimum goal was set of providing protection for a five-year frequency flood by the winter rainy season.

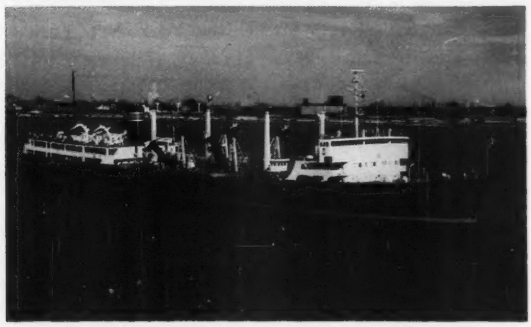
To facilitate flood plain restoration dredging in the Cowlitz, two dredges were loaded on trailers and moved by highway to operation sites, circumventing river stretches too clogged for navigation.

By mid July, all Corps hopper dredges had returned to their normally scheduled duties and the work of restoring the three rivers was assumed by nine contracted dredges in addition to contracted channel excavation work being performed by land-based equipment. ■

Corps' Dredge *ESSAYONS* Retired

Lieutenant General John W. Morris, Chief of Engineers, announced the retirement of the Army Engineers' hopper dredge *ESSAYONS,* which helped clear the Suez Canal of damage suffered in the 1956 war.

The vessel, the flagship of the U.S. Army Corps of Engineers' dredge fleet, took part in many epochal engineering events in both the continental United States and foreign waters. Its overseas work, in addition to the Suez Canal, and Guantanamo Bay, Cuba, was made possible because of its original design, as it was built especially for operations in New York Harbor where most of the material dredged is disposed of in deep water off Sandy Hook, NJ.



Its name is the motto of the Corps, which, translated from the French, means, "Let us try."

The *ESSAYONS* also saw service in the waters off each coast, with its heaviest concentration of duties on the east coast. It also served for considerable periods in the Portland District and in the New Orleans area.

Commissioned January 16, 1950, after being completed at the Sun Shipyards in Chester, PA, it was the largest dredge in the Corps fleet, with a length of 525 feet. Its capacity is 8,270 cubic yards and its speed while loaded is 12 statute miles per hour.

Its place at the head of the Corps' dredge fleet will be filled by *Eagle I,* one of the two largest split hull hopper dredges in the world. The christening of *Eagle I* took place on June 28, in New Orleans, LA.

General Morris said the *ESSAYONS* was retired because the dredging industry has demonstrated an ability to take over more of the workload which previously has been accomplished with Corps of Engineers' equipment. The Corps is phasing out the older dredges in the Corps' fleet as industry's dredging capability increases. The *ESSAYONS* was based in Philadelphia.

Through the Industry Capability Program, which was initiated in 1977, the dredging industry has been encouraged to construct new equipment and demonstrate an expanded capability which permits the Corps to reduce the number of dredges it operates. Public Law 95-269, passed in April 1978, authorizes a "minimum fleet" for the Corps which will be technologically modern and kept fully operational to provide an immediate response capability to provide for national defense and emergency needs. The law also provides that when the industry has the proven dredging capability the Corps will advertise available work and award it to the lowest responsible bidder except for the work associated with the minimum fleet of the Corps.

This modernized minimum fleet, smaller in number than the current fleet of older dredges, wil require the commissioning of some new and more efficient dredges. Three of these are now under construction. ■

Four Icebreakers Commissioned for Great Lakes

The U.S. Coast Guard commissioned four 140-foot cutters during 1979 for multipurpose use in the Great Lakes, including icebreaking operations.

The first of the group, which will include five vessels, was the **Katmai Bay,** commissioned in Cleveland, Ohio on January 8th, before going to its base at Sault Ste. Marie, Michigan. The other vessels were commissioned at their new home ports: the **Bristol Bay** at Detroit on June 16, the **Mobile Bay** at Sturgeon Bay, Wisconsin on November 17, and the **Biscayne Bay** at St. Ignace, Michigan on December 8.

The fifth cutter, the **Neah Bay,** is scheduled to be placed in service this year and will be based at Charlevoix, Michigan.

Cost of construction for each vessel was approximately $7.5 million. ■

Barge Tonnage Up in 1978

Tonnage moved by the U.S. barge and towing industry totaled 662.2 million tons in 1978, according to figures just released by the Corps of Engineers. This represents a 3.4 percent increase over the 640 million tons recorded in 1977.

The figures also reveal that the barge and towing industry moved 61.6 percent of all domestic marine traffic, which topped 1 billion tons for the first time.

Tonnage on the Mississippi River increased by 4.1 percent, primarily due to additional movements of

fuels and grains. The largest increase in exports was in prepared animal feeds, which jumped from just over half a million tons in 1977 to 8.1 million tons in 1978, according to the Corps of Engineers. Sand, gravel, and crushed rock movements rose by 2 million tons.

Most of the increased traffic occurred in the reach of the river between Cairo, IL, and New Orleans.

Among river ports, the largest percentage increase was recorded by St. Paul, MN, which posted a 42 percent increase to more than 9.6 million tons. Next were Nachez, MS, with a 39 percent gain, and Lake Providence, LA, with a 24 percent increase.

Baton Rouge posted the largest tonnage increase for a river port, with a 4-million-ton increase to 74.6 million tons.

Traffic on the Mississippi River System and its tributaries rose from 536.8 million tons in 1977 to 552.9 million tons in 1978, as ton-miles increased from 196.8 billion to 208.8 billion.

Copies of the five-part *Waterborne Commerce of the United States* for 1978, are available for sale by the Corps of Engineers. ■

Updated Endangered Species List Published

The official U.S. list of endangered and threatened wildlife and plants worldwide now carries 773 species, 276 of which are native to the United States.

"That's up 77 from last year," says Dr. Paul Opler of the U.S. Fish and Wildlife Service's Endangered Species Office, referring to the previous list published in January 1979. "But that increase has more to do with improved research than the continuing, general deterioration of the world's wildlife environment. We're simply finding more plants and animals that need to be classified."

An "endangered" species is one that is in danger of extinction throughout all or a significant part of its range. A "threatened" species is one that is likely to become "endangered."

The additions made to the list of endangered and threatened species in the last year and a half come from every part of the Earth. Two of them — Guatemalan fir and the Chilean false larch — are the first foreign plants ever to be listed. Other species include the Caribbean monk seal, West African manatee, North China sika deer, and the Kern (California) primrose sphinx moth. During the last 16 months, 36 plants (mostly cacti), 29 mammals, 9 reptiles, 4 fish, 1 bird, and 2 insects were added to the revised list.

The basic cause for endangerment of either mammals or plants is loss of habitat. *(Department of Interior)* ■

Bookshelf

The C. & 0. Canal Boatmen 1892-1924, by Thomas F. Hahn, is a paperback, first edition book of various adventures of traveling the canal that occurred during that historical period. This 84-page, illustrated book is available for $4.75 plus $1.00 shipping per order, from American Canal and Transportation Center, Box 310, Shepherdstown, WV 25443.

Marine Geodesy: An International Journal of Ocean Surveys, Mapping and Sensing, presents research on precise measurements within the ocean and from space to the ocean surface. The aim of the journal is to stimulate progress in marine geodesy by promoting problem-oriented marine geodetic research. Subscription information is available from Crane, Russak & Company, Inc., 3 East 44th Street, New York, New York 10017.

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Coming Events

Urban Lakes - Design and Management Workshop, San Diego, CA, October 11-12.

16th American Water Resources Conference, Minneapolis Radisson Hotel, Minneapolis, Minnesota, October 13-16.

"Remote Sensing in Natural Resource Management" - National Conference, Soil Conservation Society of America, Radisson Muehlebach Hotel, Kansas City, Missouri, October 28-30.

7th Conference, Prevention, Behavior, Control and Cleanup of Oil Spills, Atlanta Hilton, Atlanta, GA, March 2-5, 1981.

North American Wildlife National Resources Conference, Shoreham Americana, Washington, D.C., March 21-25, 1981.

45th Annual Meeting, National Wildlife Federation, Omni International Hotel, Norfolk, VA, March 27-29, 1981.

Water Industry, '81, International Conference and Exhibition, Metropole Convention Centre, Brighton, UK, June 15-19, 1981.

Changes of Command

President Carter has announced the selection of **Lieutenant General Joseph K. Bratton** as the new Chief of the U.S. Army Corps of Engineers. General Bratton, who was most recently South Atlantic Division Engineer in Atlanta, succeeds **Lieutenant General J.W. Morris,** who retired in September after more than 37 years of military service. Gen. Morris had earlier served as head of the Corps' Civil Works Directorate. Gen. Bratton was replaced in the South Atlantic Division by **Brigadier General James N. Ellis.**

Major General W.R. Wray has been named Deputy Chief of Engineers on Gen. Bratton's staff in Washington, D.C. He replaces **Major General J.A. Johnson,** who also retired from military service.

In other Corps of Engineer general officer reassignments, **Major General William E. Read** became Lower Mississippi Valley Division Engineer, with headquarters in Vicksburg. Gen. Read, who had previously served as the Assistant Chief of Engineers, replaced **Major General Robert C. Marshall,** who also retired.

Major General Drake Wilson was named the Director of Military Programs in the office of the Chief of Engineers. He had previously served as the Corps' European Division Engineer. His successor in that position has not yet been named.

Brigadier General Scott Smith has taken over as North Central Division Engineer in Chicago. He replaced **Major General Richard L. Harris** who has retired. Gen. Smith was formerly assigned as Assistant Division Commander, 7th Infantry Division, Fort Ord, California.

Colonel James B. Hall has been named Deputy Division Engineer for the Corps' Middle East Division (Rear), in Berryville, VA. He succeeded **Colonel Daniel D. Ludwig,** who retired in June. Col. Hall had earlier been Deputy Division Engineer for the division's forward element in Saudi Arabia.

Dr. Laurence R. Jahn, Vice President of the Wildlife Management Institute, has been named to membership on the Corps of Engineers Environmental Advisory Board. The Board was established in 1970 to make available a broad range of environmental expertise and experience and to help create mutual understanding and confidence between the Corps, the general public, and the conservation community.

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Where is the U.S. Army Corps of Engineers coming from and where is it headed? See "Reflections: An Interview With The Chief" on page 1. (C of E Photo)